

Phase 2 Remedial Investigation Report Army Materials Technology Laboratory

Task Order 1
Remedial Investigation/Feasibility Study

Contract Number DAAA15-90-D-0009

Volume 1

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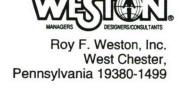
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FINAL

Task Order 1

PHASE 2 REMEDIAL INVESTIGATION FOR BASE CLOSURE REMEDIAL INVESTIGATION/FEASIBILITY STUDY ARMY MATERIALS TECHNOLOGY LABORATORY WATERTOWN, MASSACHUSETTS

Contract No. DAAA15-90-D-0009

VOLUME 1

May 1994

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AAWQC Ambient Acute Water Quality Criteria

ACGIH American Conference of Governmental Industrial Hygienists

ACM Asbestos-containing Material

ACS American Chemical Society

ACWQC Ambient Chronic Water Quality Criteria

ADL Arthur D. Little, Inc.

ADS Annular Denuder System

AEC Army Environmental Center

AHERA Asbestos Hazard Emergency Response Act

ALARA As Low as Reasonably Achievable

Alpha-BHC Alpha-benzenehexachloride

AMC Army Material Command

AMMRC Army Materials and Mechanics Research Center

ANL Argonne National Laboratory

ANSI American National Standards Institute

AQAC Analytical Quality Assurance Coordinator

AR Army Regulation

ARAR Applicable or Relevant and Appropriate Requirement

ARRP Army Radon Reduction Program

ASHRAE American Society of Heating, Refrigeration, and Air

Conditioning Engineers, Inc.

ASTM American Society for Testing Materials

atm Atmosphere

BC Base Closure

bdl Below Detection Limit

BEAG Biomedical and Environmental Assessment Group

BEIR Biological Effects of Ionizing Radiation

beta-BHC Beta-benzenehexachloride

bgs Below Ground Surface



LIST OF ACRONYMS (Continued)

BNA

Base/Neutral/Acid Extractable Organic Compounds

BTEX

Benzene, Toluene, Ethylbenzene, and Xylene

CAR

Chemical Air

CAS

Chemical Abstract System

CBI

Chemical Building Interior

CERCLA

Comprehensive Environmental Response, Compensation,

and Liability Act

Chem-Nuclear

Chem-Nuclear Systems, Inc.

cfm

Cubic Feet per Minute

CFR

Code of Federal Regulations

CGW

Chemical Groundwater

CMR

Code of Massachusetts Regulations

cpm

Counts per Minute

CPU

Central Processing Unit

CSE

Chemical Sediment

CSO

Chemical Soil

CWA

Clean Water Act

DDD

1,1-Bis(4-Chlorophenyl)-2,2-dichloroethane

DDE

1,1-Bis(4-Chlorophenyl)-2-chloroethane

DDT

1,1-Bis(4-Chlorophenyl)-2,2,2-trichloroethane

delta-BHC

Delta-benzenehexachloride

DIMP

Di-isopropylmethylphosphonate

DPH

Department of Public Health

dpm

Disintegrations per Minute

dps

Disintegrations per Second

DU

Depleted Uranium

EDM

Electronic Distance Measurer

EM

Electromagnetic

EPA

Environmental Protection Agency



ER

Effects Range

FDP

Facility Decommissioning Plan

FIDLER

Field Instrument for Detection of Low-Energy Radiation

FS

Feasibility Study

gamma-BHC

Lindane

GC

Gas Chromatography

G-M

Geiger-Mueller

gpm

Gallons Per Minute

GPR.

Ground-penetrating Radar

GSA

General Services Administration

GSSI

Geophysical Survey System, Inc.

GZA

Goldberg-Zoino Associates, Inc.

HEPA

High-efficiency Particulate Air

HI

Hazard Index

HPLC

High Performance Liquid Chromatography

HQ

Hazard Quotient

HRS

Hazard Ranking System

HUD

U.S. Department of Housing and Urban Development

ID

Inside Diameter

IRDMIS

Installation Restoration Data Management

Information System

IRP

Installation Restoration Program

LLD

Lower Limit of Detection

L/min

Liters per Minute

LQAC

Laboratory Quality Assurance Coordinator

MADEP

Massachussets Department of Environmental Protection

MAGW

Massachusetts Groundwater

MCL

Maximum Contaminant Level

MCLG

Maximum Contaminant Level Goal



MCP Massachusetts Contingency Plan
MDC Metropolitan District Commission

MDL Method Detection Limit

mmhos/m Millimhos per Meter

MOA Memorandum of Agreement

mrad Millimeters Radian mrem/yr Millirems per Year

MSL Mean Sea Level

MTL Materials Technology Laboratory

MWRA Massachusetts Water Resources Authority
NAAQS National Ambient Air Quality Standards

NCP National Contingency Plan
NDE Nondestructive Examination

NEPA National Environmental Policy Act

NGVD National Geodetic Vertical Datum of 1929

NIOSH National Institute for Occupational Safety and Health

NIST National Institute of Standards and Technology

NJDEPE New Jersey Department of Environmental Protection and

Energy

NOAA National Oceanic and Atmospheric Administration
NPDES National Pollutant Discharge Elimination System

NPL National Priorities List

NRC Nuclear Regulatory Commission

ns Nanoseconds

OSHA Occupational Safety and Health Administration

OTFL Outfall

PAH Polynuclear Aromatic Hydrocarbon

PAL Public Archaeology Laboratory

PA/SI Preliminary Assessment/Site Inspection



PCB Polychlorinated Biphenyl

PCE Tetrachloroethylene

pCi/g Picocuries per Gram

pCi/L Picocuries per Liter

PEL Permissible Exposure Level

PF Potency Factor

PIC Pressurized Ionization Chamber

PID Photoionization Detector

PM-10 Particulate Matter Less Than or Equal to 10 Microns

ppb Parts per Billion

PPE Personal Protective Equipment

PRI Potomac Research Institute

PRP Potentially Responsible Party

PTN Property Transfer Notification

PUF Polyurethane Foam

PVC Polyvinyl Chloride

QA Quality Assurance

QA/QC Quality Assurance/Quality Control

RA Risk Assessment

RAD Radiological Parameter

RAGS Risk Assessment Guidance for Superfund

RCG Radiological Concentration Guidance

RCRA Resource Conservation and Recovery Act

REL Recommended Exposure Level

RfD Reference Dose

RI Remedial Investigation

RI/FS Remedial Investigation/Feasibility Study

RNSW Rinse Water

ROD Record of Decision



RVER River

SARA Superfund Amendments and Reauthorization Act

SDWA Safe Drinking Water Act

SHPO State Historic Preservation Officer

SIR Surface Interface Radar

SOW Statement of Work

STSW Storm Sewer

SVOC Semivolatile Organic Compound

TAL Target Analyte List
TBC To Be Considered

TCA 1,1,1-Trichloroethane

TCE Trichloroethylene

TCL Target Compound List

TCLP Toxicity Characteristic Leaching Procedure

THAMA Toxic and Hazardous Materials Agency

TIC Tentatively Identified Compound

TLV Threshold Limit Value

TOC Total Organic Carbon/Also, Top of Casing

TPH Total Petroleum Hydrocarbons

TRC Technical Review Committee

TSD Treatment, Storage, and Disposal

TSP Technical Sampling Plan/Also, Total Suspended Particulate

TWA Time Weighted Average

USCS Unified Soil Classification System

USACE U.S. Army Corps of Engineers

USGS United States Geologic Survey

UST Underground Storage Tank

VOA Volatile Organic Analysis

VOC Volatile Organic Compound



WESTON

Roy F. Weston, Inc.

WHO

World Health Organization

 $\mu Ci/mL$

Microcuries per Milliliter

 $\mu g/g$

Micrograms per Gram

 μ g/L

Micrograms per Liter

 μ g/m³

Micrograms per Cubic Meter

Executive Summary



Phase 2 of a remedial investigation (RI) has been conducted at the U.S. Army Materials Technology Laboratory (MTL) in Watertown, Massachusetts. The U.S. Army Environmental Center, New England Division, contracted with Roy F. Weston, Inc. (WESTON) under the Base Closure Program Contract Number DAA15-90-D-0009, Task Order 1, to complete, among other tasks, the Phase 2 RI at MTL.

After the Phase 1 RI was initiated, MTL was recommended for closure by the Defense Secretary's Commission on Base Realignment and Closures. The original objectives of the Phase 1 RI did not include assessing concerns associated with future unlimited use of the site by the public after the closure of MTL. To do so, sampling in buildings, as well as more extensive environmental sampling and risk assessment, was required. This additional information was collected during the Phase 2 RI to properly evaluate potential remedial measures that would allow subsequent land use consistent with assigned reuse.

The objectives of the Phase 2 RI were:

- To characterize areas not addressed in the Phase 1 RI.
- To investigate further the nature and extent of contamination uncovered in the Phase 1 RI.
- To evaluate potential human health and environmental risks from present and likely future use of the site.
- To provide a basis for decisions concerning the need for and type of remedial measures.

To accomplish the objectives of the Phase 2 RI, the following investigations were conducted:

- Geophysical investigation of sewer lines, underground storage tanks, and fill areas.
- Sampling of surface and subsurface site soil.
- Sampling of groundwater from both shallow and deep zones.
- Measurement of groundwater levels in wells and subsequent determination of groundwater flow direction and velocity.
- Inspection and sampling of Charles River surface water and sediments upstream and downstream of MTL storm sewer outfalls.



- Sampling of water and flow measurements in the storm sewer system running through MTL.
- Inspection and sampling of sediments in the sanitary sewer system at MTL.
- Survey of both indoor and outdoor radiological contamination at MTL.
- Sampling of indoor surfaces by wiping walls, floors, fume hoods, and other surfaces with solvent-soaked gauze pads.
- Air sampling inside MTL buildings.
- Sampling of liquids and sediments from various cisterns, tanks, sumps, and dry wells on-site.

In general, samples from all media were analyzed for volatile organics, semivolatile organics, metals, cyanide, pesticides, PCBs, and radiological parameters, usually uranium isotopes and gross alpha and beta activities. These analytes were chosen based on CERCLA guidance, historical uses of the MTL facility, and information on current chemical and radiological inventories for buildings at the site.

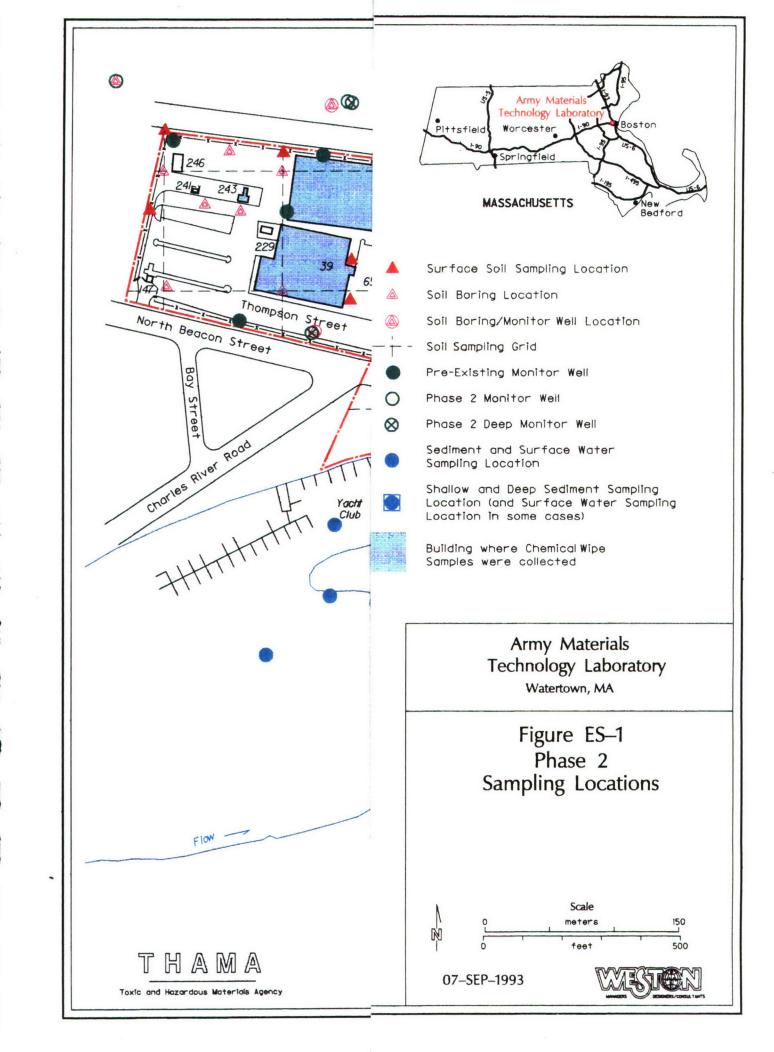
Soil, groundwater, surface water, and sediment sampling locations are summarized in Figure ES-1 and are shown in more detail in Figures 4-1 through 4-15 and in Appendix I.

EPA REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROCESS

The U.S. Environmental Protection Agency (EPA) has established protocols for the investigation and remediation of contaminated sites that, for any of a number of reasons, are included on the EPA Superfund National Priority List. Often, sites that are not on the list are investigated using EPA protocols, to ensure a consistent, comprehensive approach to site cleanup.

The type of investigation conducted using the EPA guidance described above is known as a remedial investigation/feasibility study (RI/FS). The RI/FS process begins with an investigation of site historical data, including maps; photographs; aerial photographs; public documents such as newspaper articles; existing reports on environmental or other studies conducted at the site; raw material inventories; regional and local (if available) hydrogeological, historic, and meteorological data; and employee interviews.

Using information gathered during this initial process, a Technical Sampling Plan is developed which describes media to be sampled, sample numbers and locations, sample collection procedures, field personnel health and safety protocols, laboratory analytical procedures, data tracking procedures, and, most importantly, objectives for the use of the data gathered. The objectives are determined by using a conceptual site model that delineates contaminant types, sources, and possible exposure pathways.





Once the Technical Sampling Plan is approved by the public or its technical representative and various regulatory agencies, field sampling is conducted. The data collected are interpreted by comparison to regulatory standards and incorporation of the data into both human health and ecological risk assessments. Conclusions are drawn as to the significance of the site contamination and its associated risks, and recommendations regarding the need for remediation are made. The information is compiled in a remedial investigation report, which is reviewed by the public and regulatory agencies.

The results, conclusions, and recommendations of the remedial investigation report are used in developing remediation alternatives in the feasibility study. In this study, the universe of applicable technologies is evaluated and screened. A number of technologies can be eliminated immediately, due to such factors as infeasibility of implementing a particular technology because of access problems, type of contamination, or regulator policy regarding the technology. The remaining technologies are assembled into sitewide remedial alternatives. These alternatives are evaluated based on comparisons between implementability, cost, regulatory compliance, effectiveness, etc. This entire process is presented in a feasibility study report, which is reviewed by the regulators and the public. One or more alternatives (depending upon how many different media must be remediated) are chosen for site implementation. Once the chosen alternative(s) is/are reviewed by the public, a Record of Decision is written and maintained in the regulatory files.

INSTALLATION PROFILE

The MTL facility has been in operation since 1816. It was established for the purposes of storage, repair, cleaning, and issue of small arms and ordnance supplies. Throughout the 1800s and until World War II, MTL's mission was continually expanded to include weapons development and production, and materials research experimentation and development. At the height of its activity (just after World War II), the site encompassed 131 acres with 53 buildings and structures and employed 10,000 people. In 1960, the Army's first nuclear materials research reactor was constructed, and it was used in research activities until its deactivation in 1970. Decommissioning of the reactor, in accordance with the Nuclear Regulatory Commission standards, is proceeding. MTL currently executes the Army's primary mission in materials research and development, solid mechanics, testing technology, and lightweight armor development.

An operational phaseout of the arsenal was begun in 1967. At that time, approximately 55 acres of land were sold to the town of Watertown, and 28.5 acres were transferred to the General Services Administration (GSA). The parcel sold to Watertown currently contains a shopping mall, condominiums, and a public park and playground. Land transferred to GSA has undergone various improvements, including paving in some portions.

MTL currently occupies 36.5 acres and is bounded on the north by Arsenal Street and a commercial area, on the west by commercial and residential property, and on the east



by condominiums and a park. To the south of the site, along the Charles River, are 11 acres of land controlled by the Commonwealth of Massachusetts and containing a public roadway (North Beacon Street), a public park, and a yacht club. MTL contains 15 buildings and 15 associated structures.

PHYSICAL CHARACTERIZATION

MTL is located in an urbanized area. The site, located on a former low bluff of the river, is generally flat, sloping slightly toward the river. As a result of more than a century of construction, most of the original topography has been covered by sand and gravel fill and construction debris. With the exception of a narrow strip of land along the river, the MTL property and its adjoining 11 acres to the south lie outside of the 500-year flood zone.

Facility surface drainage is primarily to the south, towards the river. An extensive onsite storm sewer system directs rain and snow runoff to the Charles River through several outfalls.

Recently, the classification of the Charles River has been upgraded by the Massachusetts Department of Environmental Protection (MADEP), such that the water is deemed acceptable for swimming and other recreational purposes, due to a reduced level of coliform bacteria. Most surface water quality parameters, measured at a sampling station approximately 25 miles upstream of the facility and the adjacent industrial areas, fall within acceptable levels for this classification.

Geologically, the facility is located in the north-central portion of the Boston Basin. Soils at MTL are classified as Merrimac gravelly sandy loam, although they have been significantly altered as a result of numerous construction and fill activities. Much of the site is overlain by over 10 ft of sand and gravel fill material. This fill is underlain by less coarse glacial till deposits.

Deep soil borings indicated that bedrock depth ranged from approximately 50 ft at the western end of the site to approximately 100 ft at the eastern end. The bedrock surface sloped generally to the south-southeast. These findings agreed for the most part with the geophysical investigation of bedrock depth and slope during Phase 1.

Depth to groundwater ranged from approximately 4 ft in the southeastern corner of the site to approximately 24 ft in the northwestern corner. Two water-bearing zones (one shallow and one deep) exist within the aquifer. These zones appear to be hydrogeologically connected. Groundwater flow is generally to the south-southeast towards the Charles River in both the shallow and deep water-bearing zones.

GEOPHYSICAL INVESTIGATION

A geophysical investigation using ground-penetrating radar and/or an electromagnetometer was performed over portions of the site to assist in locating the following:



- Suspected underground storage tanks
- Fill areas
- Sewer line junctions

Since geophysical methods are not exact, they were used in conjunction with site sampling results to draw conclusions about the areas investigated.

The parking lot between Buildings 37 and 131 was surveyed for the presence of an underground storage tank. Elevated conductivity readings, perhaps indicating buried metal, were detected in the northern end of the lot. This area is probably an underground storage tank, since aerial photographs show what appears to be a gas pump located approximately 100 ft southwest of this disturbed area and since a monitor well downslope of the area contained some volatile organic compounds associated with fuel products.

The park along the Charles River, the on-site area north of North Beacon Street, and the areas south and west of Building 60 were surveyed for the presence of fill. More than half of the park area (primarily in the western portion) consists of disturbed soil or fill. Measurements suggesting buried metal were recorded in the northwestern and northeastern corners of the surveyed area of the park and in a small area in the center of the park. Areas north of North Beacon Street also contained disturbed soil or fill. High conductivity readings were detected near the propellant storage area and near the steep bank to the north, suggesting the presence of buried metals. Three disturbed areas were located near Building 60. The hillside and flat area southwest of the building appear to be all fill, and slag was observed on the hillside.

Visual inspection and ground-penetrating radar were used to revise the understanding of the piping configuration at five sewer junctions where discrepancies existed between site sewer maps and diagrams by A.D. Little from the Phase 1 RI. Based on the current understanding of existing site maps, the ADL diagrams, and Phase 2 data, some of the representations of sewer junctions on existing facility blueprints are incorrect.

SOIL INVESTIGATION

Sampling Program

A soil sampling program was carried out to identify and delineate potential soil contamination throughout the facility. A facilitywide grid system (sampling on 300-ft centers) not biased toward areas of suspected contamination was used to collect data throughout the MTL property. Additional borings were installed in areas where contamination had been identified in previous studies or near locations where hazardous or radioactive constituents may have been stored or used. Subsections 2.3 and 4.3 of this report discuss the details of the soil investigation. Figures 4-7 and 4-8 depict the sampling locations.

The 62 soil borings were advanced from ground surface to the water table using a continuous split spoon sampling technique. In addition, 30 surface soil samples were



collected using stainless steel bowls and scoops. A total of approximately 180 soil samples were submitted for laboratory analysis for the following parameters: volatiles; semivolatiles; cyanide; metals; pesticides/PCBs; radiological parameters, including gross alpha and beta; and uranium isotopes U-234, U-235, and U-238. In addition, selected soil samples collected from 18 of the soil borings were analyzed for total organic carbon.

On-site sample results were compared to the Massachusetts Contingency Plan Method 1 Soil Standards for discussion purposes only. The risk assessment used background concentrations based on sampling results from upgradient soil samples to assist in determining site-related compounds. Background samples are those samples located in such a way as to be uninfluenced by site activities. As such, these samples do not have to be off-site, but merely located away from and/or upslope or upgradient of site operations. In addition, background samples need not be pristine, just outside of site influence. Upgradient samples are located based on groundwater flow direction. For a sample location to be considered upgradient of a site, groundwater must flow from the sample location towards the site.

For soil, the following potential exposure pathways and exposure routes were evaluated:

- Future child and adult site residents ingestion of and dermal contact with yard soil and soil in the park areas. Ingestion of vegetables grown in contaminated soil was also evaluated. Exposure to excavated soil (0 to 12 ft deep) was considered where appropriate.
- Future commercial office workers soil ingestion.
- Future construction workers soil ingestion and inhalation of soil dust.

Sampling Results

Soil samples collected from beneath concrete floors in Buildings 43, 311, and 312 showed elevated concentrations of semivolatile organic compounds. Contaminant concentrations were generally highest at ground surface. Elevated concentrations of polycyclic aromatic hydrocarbons (a subgroup of semivolatiles typically found in petroleum distillate products or other petroleum-related products such as coal tar or asphalt) were detected in soil samples collected from borings completed in the grassy area between North Beacon Street and the Charles River. The highest levels of polycyclic aromatic hydrocarbons were detected adjacent to Buildings 39 and 227/60, and in the parking lot between Buildings 37 and 131. Analytical results showed that the total uranium activity in all soil samples was below the federally mandated maximum allowable total activity for DU of 35 pCi/g for soil (46FR 52061). Metals concentrations, primarily beryllium, were reported above MCP Soil Standards in shallow (less than 1 ft) soil samples collected from immediately outside Buildings 39, 43, 311, 313, and 656. Pesticides were detected in surface soil samples, particularly in the grassy areas within the southeast and central portions of the site and along the southern fence line.



Approximately 177 tons of soil contaminated by a leak of No. 6 fuel oil on the north side of Building 227 were excavated by a contractor to MTL to a depth of 14 ft. When the excavation threatened the structural integrity of Building 227, it was discontinued. Results of samples taken from the excavation piles indicated the presence of fuel-related compounds. Further remediation of the area will be addressed in the feasibility study.

Risk Assessment for Exposure to Soils

Four major reuse zones were identified by the Watertown Arsenal Reuse Study as the most likely future uses of the site (see Figure 6-2). These areas, with the addition of the grassy area along the river, were used to evaluate potential future exposures in the risk assessment.

MADEP considers any site risk from exposure to carcinogens in excess of 1 in 100,000 as an unacceptable risk. The EPA action level for risk is 1 in 10,000.

Potential carcinogenic risks for future resident adults and children due to soil exposure in each of the four zones exceeded 1 in 100,000. Where gardening was considered as part of the future residential use (Zones 1 and 4), exposure through consumption of vegetables was the most significant exposure pathway, with risks exceeding 1 in 10,000. If Zone 4 were not further developed as a residential area and deeper soils (below 2 ft) were not excavated and spread on the surface, potential risks were calculated to be less than 1 in 100,000. Potential carcinogenic risks in Zones 2 and 3 exceeded 1 in 100,000 primarily due to the potential ingestion of soil.

Potential exposures to soils for future commercial workers would produce estimated risks in excess of 1 in 100,000 for exposure to Zone 3 soils, but not for Zone 1 or 2. Construction worker scenarios produced estimated risks of less than 1 in 100,000.

Analytical results showed very little evidence of radioactive isotope concentrations above background. Risk assessment results did not indicate any health risks in excess of 1 in 100,000 as a result of the presence of radioactive isotopes.

For noncarcinogenic risks, MADEP considers a hazard index (sum of the ratios between the assumed daily intake of a substance and the maximum daily dose that could be incurred without deleterious health effects for all substances considered) of 1.0 or less to be unlikely to cause any health effects. Metals concentrations were reported above background in shallow (less than 1 ft) soil samples collected from immediately outside Buildings 39, 43, 311, 313, and 656. Risk assessment results indicated that elevated metals concentrations in soil do not pose a significant noncarcinogenic risk to humans (hazard quotient less than 1.0).

Noncarcinogenic pesticides were detected in surface soil samples, particularly in the grassy areas within Units 13, 14, 15, and 16. Noncarcinogenic hazard index values slightly exceeded 1.0 under potential residential exposure to excavated (surface and deep) soil in Zone 4 (hazard index = 2). This hazard index was primarily the result of



ingestion of vegetables potentially grown in contaminated soil. All other zones and scenarios produced estimated hazard indices of less than 1.0.

The UBK model predicted acceptable blood lead levels for future residents; however, at least one location near Building 656 may require further confirmation/remediation.

Recommendations

Results from soil borings located adjacent to active buildings at MTL indicated that polycyclic aromatic hydrocarbons and, to a lesser extent, Aroclor 1260 and dieldrin, are responsible for most of the potential cancer risks. The highest levels of PAHs were detected adjacent to Buildings 39, 227/60, and under the parking lot between Buildings 37 and 131.

Because the potential cancer risks associated with these chemicals are in excess of the risk allowed by Massachusetts, and because some chemicals also exceeded the MADEP soil action levels, it is recommended that remediation of the soils in these areas be considered prior to the sale of the facility. The type of remedial action of soils in excess of the risk allowed by Massachusetts will be evaluated in the FS. It should be noted, however, that most of the excess cancer risk is posed by consumption of vegetables grown in contaminated soil. Restrictions on growing vegetables in Zone 1 would suffice to reduce the risk to acceptable levels.

GROUNDWATER INVESTIGATION

Sampling Program

An investigation was carried out to characterize groundwater upgradient of and beneath the facility. The present investigation consisted of installing 15 groundwater monitoring wells, while an earlier Phase 1 investigation consisted of installing 16 wells. One groundwater sampling round was completed and groundwater samples from the 31 wells were submitted to a laboratory for analysis of volatiles, semivolatiles, metals, cyanide, pesticides/PCBs, and radiologic parameters, including gross alpha, beta, and gamma activity and uranium isotopes U-234, U-235, and U-238. Sampling locations and procedures are discussed in Subsections 2.4 and 4.4. Figures ES-1 and 4-9 depict these locations.

Assessment of groundwater consisted of comparing the analytical results to MCP groundwater standards and Massachusetts groundwater standards. No RA was completed for groundwater because groundwater in the vicinity of the site is not used as a water source and will not be used as one in the foreseeable future. Watertown is a MWRA member community and obtains its water supply from several reservoirs in Massachusetts.



Sampling Results

With the exception of one well, all upgradient wells showed detectable quantities of chlorinated solvents. Chlorinated solvents (solvents commonly found in industrial degreaser solutions) identified in upgradient wells include tetrachloroethylene, trichloroethylene, and 1,1,1-trichloroethane.

In addition, one upgradient well showed elevated concentrations of gasoline-related volatile organics. Based on a site water table map, groundwater flow paths indicate the potential of groundwater flowing away from the site in an area in the northwest part of the site before flowing towards the Charles River. No evidence of on-site contamination migrating off-site was found in groundwater collected from on-site wells. Most likely, a groundwater divide exists under a short stretch of Arsenal Street near the northwestern corner of the site. In general, however, groundwater flows from north of Arsenal Street to the site.

Chlorinated solvents including trichloroethylene and tetrachloroethylene were detected in groundwater samples collected from 12 on-site monitor wells. Monitor wells located in the western portion of the site reported the highest concentrations of tetra- and trichloroethylene. Few exceedances of proposed groundwater standards occurred.

Elevated concentrations of semivolatile 1,3-dimethylbenzene and volatile xylene were detected in one well located in the central portion of the site. Based on a petroleum odor present during groundwater sampling, contamination is believed to be the result of a fuel oil release. Analytical results from nearby monitor wells suggest the elevated concentrations are restricted to the area around this well.

When completing a soil boring beneath the Building 36 parking lot, several inches of free product were observed at the water table. Analysis of a soil sample collected at the water table indicated the contaminant was a fuel oil product. The sample did not contain the more commonly known gasoline-related compounds (benzene, toluene, ethylbenzene, and xylene), but it did contain certain compounds found in some of the heavier fuel oils such as phenanthrene, fluoranthene, and pyrene. This oil may be No. 6 fuel oil resulting from a pipe release in the area of Building 227; however, the boring in which the free product was found is slightly upgradient of the release, and therefore, the contamination in the central well may be from another source. Groundwater samples collected from downgradient monitor wells did not detect evidence of the free product, indicating that there has not been contaminant migration in this direction. To determine more precisely the contaminant plume configuration, additional observation wells will be required.

Groundwater Recommendations

Chlorinated solvents (tetrachloroethylene and trichloroethylene) were detected in 12 onsite monitor wells. The impact of chlorinated solvents in locations where regulatory standards of organic compounds were exceeded should be evaluated in the FS. Other monitor wells were identified where groundwater exceeded groundwater standards.



High concentrations of 1,3-dimethylbenzene (xylene) were detected in groundwater collected from a well in the central portion of the site. Based on additional groundwater monitoring and soil boring work completed in the area around this well, the contaminant plume is not believed to have migrated beyond the immediate area. The impact of this contaminant should be evaluated in the FS.

To better determine the plume configuration in the vicinity of the boring beneath the Building 36 parking lot, additional soil borings should be installed.

CHARLES RIVER INVESTIGATION

Sampling Program

Surface water and sediment samples were collected at locations upstream and downstream of the storm sewer outfalls at MTL to determine what impact, if any, the runoff from the installation has had on the Charles River. Surface water and sediment samples were collected from a total of five locations upstream of MTL storm sewer river outfalls. Sediments were also collected from 14 downstream locations (9 of these were also sampled for surface water). Sample locations and sample collection protocols are discussed in Subsections 2.5 and 4.5. Figures ES-1 and 4-10 depict the sample locations. Samples were analyzed for volatile organics, semivolatile organics, metals, cyanide, pesticides, PCBs, and radiological parameters (uranium and gross radiological activity). In addition, some samples were also analyzed for total organic carbon. Chemical data from the downstream samples for surface water were compared to available EPA and Commonwealth of Massachusetts criteria for protection of aquatic life or human use of the river. A baseline risk assessment for human health (Section 6) and an ecological assessment for MTL (future addendum) on the potential effects to native plants and animals were developed using the levels of contaminants found in the Charles River surface water and sediment samples. Both were performed in accordance with MADEP Risk Assessment Guidance. The sediment data were compared to the available Draft National Sediment Quality Criteria (currently established for five compounds).

Sampling Results

Ten metals and one organic compound were detected in the surface water samples collected from the upstream sampling locations. Sediments collected from the same five locations contained 15 semivolatile organic compounds and 19 metals. Many of the semivolatiles detected in the upstream sediments are contained in petroleum products. This, together with the observation of evidence of the long-term deposition of dark-colored organics (possibly heavy oil) indicate that the area immediately upstream of MTL has been influenced by the practices at the adjacent yacht club (see Figure ES-1 or Figure 4-10 for the location of the yacht club).

Eight metals were detected in downstream surface water samples at levels exceeding upstream concentrations. Of these, only chromium was detected in the downstream locations without also being detected in the upstream locations. Four organic



compounds (toluene, ethylbenzene, xylene, and trichloroethylene) were detected in downstream surface samples, but not in the upstream samples. The first three compounds, are thought to be associated with fuel-related activities (e.g., filling fuel tanks on boats) at the yacht club.

In downstream sediment samples, 19 metals, 20 semivolatile compounds, and cyanide were detected. A total of 14 of these exceeded the upstream concentrations. Silver, anthracene, naphthalene, dibenzofuran, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and cyanide were detected in downstream samples, but not in the upstream samples.

Detected radionuclides exceeded the upstream concentrations in both surface water and sediments. These exceedances occurred in only five locations (mostly locations near storm sewer outfalls).

In summary, river contamination exists both upstream and downstream of MTL. The majority of the surface water contamination is located downstream of MTL influence, while much of the sediment contamination (especially fuel-related compounds) is upstream of MTL outfalls.

Another round of surface water sampling was performed in September 1993 in order to achieve lower detection limits for five metals. In all cases, lower detection limits were achieved so that Ambient Water Quality exceedances could be assessed. The results of this effort will be discussed in the Addendum to the RI, which will contain the Environmental Evaluation.

Risk Assessment for Charles River Exposures

Risk scenarios were developed consistent with the Charles River classification by the Commonwealth of Massachusetts as a Class B river that is designated suitable for bathing and recreational purposes, public water supply with treatment, fish and wildlife habitat, and certain agricultural and industrial uses.

Risk levels were developed for the following Charles River exposure pathways:

- Ingestion of/dermal contact with surface water and sediment while swimming.
- Consumption of fish.

The levels of risk derived from these exposure pathways and the concentrations of compounds found in samples at or downstream of MTL are as follows:

• The total potential carcinogenic risk for recreational use of the Charles River was less than 1 in 100,000 and, therefore, less than the federal level of 1 in 10,000. The total estimated carcinogenic risk was 2 in 1,000,000 primarily as a result of potential ingestion of sediment.



• The total hazard index for potential noncancer risks for the use of the Charles River was approximately 0.02 and, therefore, was less than the state limit of 1.0.

The ecological assessment for MTL, focusing on the potential effects on plants and animals from contaminants found in the Charles River surface water and sediment samples, will be updated in an addendum to this RI report.

Recommendations

Levels of background and site-related contaminants in the Charles River surface water and sediment may have some adverse ecological effects; however, even with upgradient and site-related impacts combined, the estimated human health risk levels for use of the Charles River were less than the 1 in 100,000 guideline used by the Commonwealth of Massachusetts. In addition, remedial measures (e.g., dredging) in the Charles River would further disrupt the current ecosystem in the river and disperse additional contaminants; therefore, no remedial action is currently recommended for the Charles River. A final decision regarding remediation will not be made until the ecological assessment has been completed.

STORM SEWERS INVESTIGATION

Sampling Program

The storm sewer investigation consisted of flow monitoring and sampling of storm sewer runoff during a rain event, and an internal TV inspection to investigate the integrity of the lines and possibility of groundwater infiltration. Background sampling points were used to determine the flow and contaminants contributed from off-site. Subsections 2.6 and 4.6 discuss the storm sewer investigation program in detail. Sample locations are shown in Figure 4-11.

Sampling Results

The storm sewers contained little or no sediment; therefore, only liquid samples were obtained during the rain event. Sampling results indicate that the site contributes small amounts of some metals and pesticides to the storm sewer runoff. The only metals that exceeded two times the maximum background values were copper and zinc, both of which also exceeded the typical urban runoff range. Confirmed pesticides concentrations exceeding two times background concentrations were alpha-, beta-, and delta-BHC; chlordane; DDE; and methoxychlor. No radiological contamination was discovered.

Three storm sewer segments were inspected using television. The TV inspection revealed that the lines were in good condition with some cracks attributed to natural deterioration. The cracks were found along the joints and sides of pipe constructed of vitrified clay and brick. Although cracks were found, there was no evidence of groundwater infiltration, past or present, in any of the segments investigated.



Recommendations

Access to the storm sewer is very limited; therefore, calculation of potential risks from long-term exposures is not appropriate. Potential risks from use of the Charles River where the storm sewer lines discharge were calculated (see Subsection 8.4); however, the risks calculated for Charles River use scenarios incorporate chemical and radiological contamination from numerous upstream sources (in addition to MTL storm sewer outfalls). Because of this and because very little sediment exists in the storm sewers, no remediation is recommended.

SANITARY SEWERS INVESTIGATION

Sampling Program

Sanitary sewers were investigated for radiological contamination. Sediment samples were collected from 12 sanitary sewer manholes. Depleted uranium contamination was present in several manholes. The sampling program is discussed in Subsections 2.7 and 4.7. Sample locations are shown in Figure 4-12.

Sampling Results

On Arsenal Street, uranium was found in a manhole connected to the drainlines from Building 43. Since uranium concentrations in two manholes upstream of Building 43 are lower, the contamination in the manhole connected to the drainlines from Building 43 appears to have been augmented by sources in Building 43.

On North Beacon Street, uranium contamination was found in several manholes. Manhole 120 is the furthest upstream sample taken on the North Beacon Street sanitary line. The source of this contamination is unknown at present. Further sampling of manholes upstream of Manhole 120 will be performed, as well as tracing (using dye testing or an equivalent method), if possible, to locate any potential on-site sources of contamination.

Two sanitary sewer line segments were inspected using TV. The sanitary lines are in good condition with some cracks, as in the storm sewer lines. There was no evidence of past or current groundwater infiltration into the sanitary sewer lines. Because of the apparent integrity of the lines, infiltration of the contamination into the surrounding media is not likely.

Access to the sanitary sewer is very limited, so calculation of potential risks due to long-term exposures is not appropriate. Elevated levels of lead were found in several sewer sediment samples; therefore, the issue of remediation of chemical contamination in the sewers may have to be dealt with separately. It has not been determined whether the source of lead contamination is upstream of MTL or site-related. Removal of additional contaminated sediment will be evaluated in the FS.



Recommendations

No Nuclear Regulatory Commission action levels currently exist for radioactivity in sanitary sewer sediments. WESTON has proposed maximum allowable levels based on background data and on the available literature (WESTON, April 1992). A Nuclear Regulatory Commission ruling on the acceptability of these levels is currently pending. Based on this ruling, remediation of sewer sediments may be required. It is not anticipated at this time that remediation will be necessary. In any case, sediments in sanitary sewer lines under much of Arsenal Street and North Beacon Street were already removed and drummed to allow a camera inspection of the lines. Radiologically contaminated sediments in these drums will be properly disposed of off-site.

RADIOLOGICAL INSTRUMENT AND WIPE SURVEYS

The contaminated and suspected buildings were radiologically decontaminated during the period of August 1992 to May 1993. Each building was remediated and resurveyed to ensure that cleanup goals were met. Therefore, the description of radioactive contamination is no longer applicable. The extent of contamination observed during the Phase 2 RI is described here, but the description is not indicative of current conditions.

Survey Program

In addition to the soil, surface water, sediment, air, and sewer samples analyzed for radiological parameters, the following radiological investigations were conducted:

- Field instrument survey of the site grounds (outdoor survey).
- Survey of indoor surface contamination using instrument surveys and swipe sampling of surfaces.
- Performance of borehole gamma radiation logging.
- Performance of radiological contamination removability studies for select floor and wall areas, drains, and laboratory benches.
- Survey of building roofs and rafters.
- Survey of steam tunnels.

The field instrument survey of the site grounds (outdoor survey) indicated that the only outdoor surface gamma contamination was found in asphalt-covered areas, with one exception, in soils outside the northwest corner of Building 39 south of Structure 229. Therefore, this contamination could possibly be attributed to elevated levels of natural uranium in the asphalt. In any case, with the one exception noted, it is doubtful that the elevated outdoor readings noted are a result of site operations. It is not anticipated that any remediation will be required.



The building interior instrument survey and swipe sampling program, the roof and rafter survey, and the removability study indicated that remediation of surface contamination in several areas was required and could be accomplished. These surfaces were cleaned to levels below appropriate Nuclear Regulatory Commission standards. Buildings requiring remediation include 37, 39, 43, 97, 292, 311, 312, and 313. Areas within the buildings that required remediation included walls, floors, sumps, roofs, rafters, and drain pipes. These remedial activities are discussed in the Facility Decommissioning Plan (WESTON, 1992) and are completed and awaiting approval of the termination survey under the direction of the Army Corps of Engineers, New England Division.

Risk of Exposure to Radiological Contamination

Radiological sampling of the various environmental media at the site (Charles River, surface and subsurface soils, storm sewers, and groundwater) and of the indoor air and the containers indicated that detectable levels of radiological parameters do exist in select samples, but at low concentrations that do not pose a human health risk at MTL, even under hypothetical future residential use of the site (see Subsection 6.7). The risk from residual radiological contamination of indoor surfaces is still being evaluated.

Recommendations

The radiological investigation can be divided into two sections: environmental media, when the need for remediation is based on the risk assessments; and buildings to be remediated as part of facility decommissioning, where remediation is based on cleanup standards as established by the Nuclear Regulatory Commission and Massachusetts Department of Public Health. No remediation is required in environmental media at MTL due to radioactivity, but remediation was performed in various operations areas of the site as part of decommissioning. Decommissioning activities have been documented in the termination survey reports prepared for the USACE, New England Division. The MADEP is reviewing the 10 MREM standard used during the decommissioning process. The MADEP is in the process of determining if this standard is adequately regulated in accordance with the Massachusetts Contingency Plan.

INDOOR SURFACE CHEMICAL INVESTIGATION

Sampling Program

Indoor surface chemical wipe samples were taken from 855 locations in 17 buildings/structures at MTL and 4 off-site (background) buildings. Indoor surface sampling procedures and locations are discussed in Subsections 2.9 and 4.9. The on-site sample locations are depicted in Appendix I.

Sampling Results

Background samples taken off-site contained a total of 6 organic and 16 inorganic contaminants. Since neither the EPA nor the MADEP has promulgated guidelines or



protocols for allowable surface contamination, the wipe sample results could not be evaluated in the baseline risk assessment; however, guidelines were calculated based on protocols used by the State of New Jersey to establish surface contamination action limits. These guidelines and their associated action limits are health-based values. Contaminants that exceeded the calculated guidelines were considered elevated. Conclusions from the on-site surface wipe investigation are discussed below:

- Rooms in Buildings 111, 118, 131, 243, 292, 311, 312, 313, 36, 37, 39, 43, and the bunkers had levels of at least one analyte in samples above calculated guidelines.
- Buildings 243, 292, 311, 312, 313, 37, 39, and 43 had the most analytes above calculated guidelines.
- Many occurrences of elevated levels of chemicals were consistent with past uses in the particular buildings or rooms. For example, rooms in Building 312 were the only locations where wipe samples contained elevated levels of beryllium.

Recommendations

The MADEP is in the process of preparing a risk assessment guidance for indoor chemical contamination. Once completed, risks will be calculated based on the indoor sampling data. Cleanup levels will be calculated as part of the indoor FS report. Some areas will already have been remediated as part of the facility decommissioning, due to the presence of low-level radioactivity on various surfaces. These areas include rooms/areas in Buildings 39, 43, 97, 292, 311, 312, and 313. Potential remedial methods for surficial radiological contamination are outlined in the Facility Decommissioning Plan (WESTON, 1992). Further remediation will be evaluated in the feasibility study.

AIR INVESTIGATION

Sampling Program

Air samples were collected from Buildings 36, 37, 39, 43, 60, 97, 131, 241, 243, 292, 311, 312, and 313. Samples were analyzed for volatiles, semivolatiles, metals, explosives, and radiological parameters. Samples were collected as 24-hour composites, and sample receptacles were placed in central locations in each building so as to assess the air within the building as a whole. Air sampling procedures and locations are discussed in Subsections 2.10 and 4.10. Sample locations are depicted in Figure 4-14 and in Appendix I. Background samples were collected from six outdoor areas on-site. Results of background samples were compiled. For each sample and for each chemical or radiological component, comparisons of analytical results to MADEP 1990 background volatile organic sample results from two outdoor sampling stations in the greater Boston area and occupational health standards and public health guidelines were exceeded.



Sampling Results

In no instance were public health guidelines or occupational exposure limits exceeded. While nearly all buildings sampled contained volatiles, semivolatiles, and metals, the most prevalent contaminants were volatiles. Possible sources of the volatiles in site buildings (especially Buildings 39, 43, and 60) include solvents and other chemicals currently in use in the buildings; fugitive emissions from the boilers in Building 60; sources outside of the site, such as cars passing by the base; and emissions from other industrial sources outside the base. It should be noted here that in many instances the outdoor background on-site air samples contained higher concentrations of contaminants than did the indoor samples.

Recommendations

For the following reasons, remediation of indoor air at MTL is not recommended:

- No health guidelines were exceeded.
- The cessation of current site activities and remediation of indoor surfaces would eliminate the presence of on-site surficial contamination that may become airborne.
- In many instances, outdoor levels exceeded those indoors. It is believed that most of the air contamination is from outdoor air entering the buildings.

Rather than remediate interior air, it is recommended that if building surfaces require cleaning (see Subsection 8.8), the air be monitored during and after remediation.

CONTAINER INVESTIGATION

Sampling Program

A total of 26 cisterns, tanks, sumps, and dry wells were sampled as part of the Phase 2 RI effort (11 outdoor and 15 indoor). Depending on their availability at the time of sampling, both water and sediment samples were collected. Where sample volume permitted, samples were analyzed for volatile and semivolatile organics, metals, pesticides, PCBs, and radiological parameters. No background data were available (the purpose of containers of this sort is to contain potentially contaminated liquids, and therefore a "background" container sample is not possible).

Sampling Results

Results of sampling indicated that containers in or associated with buildings historically engaged in radiological laboratory or manufacturing processes contained radiological contamination, usually in the form of depleted uranium. Radiological contamination in the reactor area was composed of other radioisotopes, such as cesium and thorium.



Data from 23 of the 26 containers sampled indicated that one or more metals regulated under the Resource Recovery and Conservation Act were detected. PCBs were detected at levels above background levels in three of the containers sampled. Several outdoor container samples contained various pesticides (samples from the dry well near the propellant storage area and samples from Cistern 243). This is expected when infiltration of outdoor overland flow into the containers is considered. Polycyclic aromatics (a subgroup of the semivolatiles) were detected at concentrations exceeding background tolerance in three containers sampled. Volatiles were detected at concentrations exceeding background in only two containers sampled.

In addition to the cisterns, tanks, sumps, and dry wells at the site, there were six underground storage tanks dispersed throughout the site. These tanks were used to store either fuel oil for use in the buildings or mineral oil (some used as quench oils in site operations). As of the writing of this RI, all six have been emptied and removed from the site.

Risk Assessment for Container Contamination

A number of analytes, compounds, and radionuclides were detected; however, the likelihood of human exposure to these contaminants is extremely low. For this reason, container samples were excluded from the risk assessment calculations in Section 6, and no human health or ecological risks for these sources were computed. Additionally, these results must be considered in light of the fact that the background sample population does not exist.

Recommendations

One would expect to find chemicals in cisterns, sumps, etc., in an industrial setting. This, taken with the low probability of human contact with the container contents, indicates that remediation of the chemical contamination in the containers for protection of human health is not necessary.

Many of the radiologically contaminated containers were remediated as part of the facility decommissioning (WESTON, 1992). This is in large part because during decommissioning, the structures surrounding these containers were removed (reactor building) or otherwise remediated (Building 43).

Total Site Risk

Exposure profiles were developed for two residential populations — adults and children — at four zones across the site. The residential profiles included exposures both at home and at the site recreational areas. At each of these zones, carcinogenic risk estimates exceed 1E-05. Carcinogenic risks were highest at Zones 1 and 4 (2E-04 to 7E-04), where exposures to vegetables grown in contaminated soils were included. Carcinogenic risks in Zones 2 and 3 ranged from 7E-05 to 8E-05. The PAHs detected in soil are the primary contributors to this risk. Radiological carcinogenic risk estimates for residential populations were all within the acceptable range (i.e., less than



1E-05). Hazard indices calculated for resident children were all below 1E+00, except in Zone 4. At that location, an HI of 2E+00 (due to the presence of pesticides) was calculated for the vegetable pathway. Although the UBK model predicted acceptable blood lead levels for children who might live in these zones, it was recognized that at least one location near Building 656 may require further investigation if a child resident were to preferentially ingest soil from that area.

Exposures profiles were also developed with the assumption that Zones 1, 2, and 3 could be developed commercially. There appears to be no health concern for workers in a commercial setting, exposed to soil from surrounding outdoor locations except in Zone 3 where the estimated cancer risk is 2E-05. Noncancer and radiological risk estimates are all within acceptable ranges.

There appears to be no health concern for construction workers who could be exposed to site contamination during future building-type activities. Estimates for carcinogenic risk (chemical and radionuclide) are all within the acceptable risk range, as are the hazard indices.

Section 1 Introduction



INTRODUCTION

1.1 PROJECT SCOPE

Roy F. Weston, Inc. (WESTON) was contracted by the U.S. Army Corps of Engineers (USACE) Toxic and Hazardous Materials Agency (THAMA) under the Base Closure (BC) Program Contract (DAAA15-90-D-0009, Task Order 1 and its associated modifications 01 through 04) to conduct two remedial investigations (RIs) and a feasibility study (FS) at the Army Materials Technology Laboratory (MTL) in Watertown, Massachusetts. THAMA has since changed its name to the Army Environmental Center (AEC). AEC is responsible for the BC program. The objective of this program is to identify contamination resulting from past operations on Army properties throughout the United States.

Under Task Order 1, WESTON has been contracted to:

- Develop a Phase 1 RI report using existing data collected by EG&G and Arthur D. Little, Inc. (ADL) between 1988 and 1990.
- Conduct a Phase 2 RI whose field effort supplements that of Phase 1 in providing a more complete database.
- Conduct a study of potential cross-contaminated areas at MTL for use in screening remedial alternatives where mixed wastes may be involved.
- Conduct a detailed radiological survey of the facility buildings and grounds and use the data collected in a Facility Decommissioning Plan (FDP).
- Conduct an FS.
- Conduct post-FS activities, such as preparation of a proposed plan, a responsiveness summary, and a regulatory record of decision (ROD).

Fieldwork for Phase 2 was conducted between September 1991 and February 1992.

This report summarizes the investigations performed, data collected, and conclusions drawn as part of the Phase 1 and Phase 2 RIs. An FS Draft Report has been completed and will be revised based on this Final Phase 2 RI Report.



1.2 INSTALLATION PROFILE

1.2.1 INSTALLATION HISTORY

The MTL property is located on 36.5 acres of land in Watertown, Massachusetts, on the north bank of the Charles River approximately 5 miles west of downtown Boston (see Figure 1-1). The installation is bound on the north by Arsenal Street, on the south by North Beacon Street, on the east by Talcott Avenue, and on the west by the Veterans of Foreign Wars, USA, Burnham Manning Post No. 105, and private property. An additional 11 acres of federal land south of the site and abutting the Charles River are controlled by the Commonwealth of Massachusetts and consist of a public roadway (North Beacon Street), a public park, and a yacht club. Figure 1-2 provides a topographic map of the Watertown area, including the MTL site.

The facility was established as the Watertown Arsenal in 1816 by President James Madison and was originally used for the storage, cleaning, repair, and issue of small arms and ordnance supplies. During the 1800s, this mission was expanded to include ammunition and pyrotechnics production; materials testing and experimentation with paint, lubricants, and cartridges; and manufacture of breech-loading steel guns and cartridges for field and siege guns. The mission, staff, and facilities continued to expand until after World War II, at which time the facility encompassed 131 acres, including 53 buildings and structures, and employed approximately 10,000 people. Arms manufacturing continued at the facility until an operational phasedown was initiated in 1967. In 1960, the Army's first materials research nuclear reactor was completed at MTL, which was used actively in molecular and atomic structure research activities until 1970, when it was deactivated.

At the time of phasedown, much of the Watertown Arsenal property was transferred to the General Services Administration (GSA), and in 1968, approximately 55 acres were sold to the town of Watertown and subsequently used for the construction of apartment buildings, the Arsenal Mall, and a public park and playground. Of the 47.5 acres retained by the Army, 36.5 acres became the Army Materials and Mechanics Research Center (AMMRC), which was designated an historical landmark by the American Society of Metals in 1983. In 1991, the 36.5-acre parcel was designated an historical district.

In 1985, the AMMRC became MTL, which currently employs approximately 500 people and contains 15 major buildings and 15 associated structures. The current mission of MTL is materials development, structural integrity testing, solid mechanics, lightweight armor development, and manufacturing testing technology.

In October 1988, Congress passed the Defense Authorization Amendments and Base Realignment and Closure Act (Public Law 100-526). In December 1988, the Secretary of Defense's ad hoc Commission on Base Realignment and Closure issued its final report, which included a recommendation, subsequently approved by Congress, for the closure of 81 Department of Defense installations, including MTL. A closure program was initiated by AEC, which consists of three stages: preliminary assessment/site



inspection (PA/SI), RI/FS, and remedial actions. The first stage of the program at MTL, the PA/SI, was conducted by EG&G Idaho in 1987. EG&G also conducted a field program in 1988, from which an RI report was developed; however, this RI was never sent to a state or federal agency and has remained an internal draft. It was determined that chemical analyses for the 1988 sampling were not performed in accordance with the AEC Quality Assurance (QA) Program. These data could not be verified or validated by AEC and are therefore considered insupportable. Because the 1988 data are considered insupportable, a "resampling" was conducted in 1990 by ADL under contract to EG&G. This sampling was intended to duplicate, to the extent possible, the 1988 sampling effort, including resampling the 1988 sampling locations. Resampling, however, was not possible in every case. For instance, certain aqueous sewer samples could not be collected in 1990 because no flow was present at that time.

In March 1989, AEC was assigned the responsibility for centrally managing the Base Realignment and Closure Environmental Restoration Program. As a result of the closure and realignment of MTL, additional environmental investigations were mandated prior to the sale of any MTL property. As directed by AEC, WESTON has completed RI/FS efforts (initiated by EG&G Idaho in 1988) to address issues raised by the closure and reuse of MTL. The completion of these efforts includes production of a Phase 1 RI report, performance of Phase 2 field investigation activities, and production of a Phase 2 RI report, whose conclusions and risk assessment (RA) component will incorporate all Phase 1 and Phase 2 data collected to date.

1.2.2 HISTORICAL USE OF SELECTED BUILDINGS

Past and present use of the buildings investigated is discussed in the following subsections, with particular emphasis on potential sources of radiological or chemical contamination. Figure 1-3 depicts the locations of these buildings.

1.2.2.1 Building 36

Building 36 was erected in 1900. The building has undergone several renovations and additions and currently measures 110 ft by 275 ft. The building was previously used for manufacturing high-explosive and armor-piercing shells, assembling gun carriages, and storing rubber materials and gun carriage parts.

The building contains an auditorium, a library, a cafeteria, a photographic laboratory, conference rooms, and offices. There is also a mezzanine level in the library. The basement formerly held a fallout shelter.

1.2.2.2 **Building 37**

Building 37 is a two-story brick building built in 1851. It has undergone several additions and renovations and currently measures 131 ft by 315 ft. The building has housed several operations, including a machine shop, equipment maintenance shop, iron and brass foundry shops, an open hearth furnace, and general storage areas.



The building houses an automotive repair shop, storage for lawn care equipment, a carpentry shop, a paint shop, building material storage areas, risk management offices, facility maintenance offices, radiological calibration source laboratory, and automotive garages. The third-floor area is used to house the engineering plans and work-coordinating branch.

1.2.2.3 Building 39

Building 39 is a five-story building with poured concrete pillars and was constructed in 1922 as a privately owned piano factory. The building was also used as a mattress factory prior to its acquisition by the Army in 1941. In the mid-1950s, portions of the building were occupied by the U.S. Atomic Energy Commission, the U.S. Air Force Geophysics Laboratory, and the USACE Soils Laboratory and Engineering Warehouse. The types of activities performed by these agencies are unknown.

The building houses several laboratories and offices. Work performed in the laboratories includes organic synthesis research, crystallography, metals research, ceramics research, organic materials research, corrosion research, mechanics and structural integrity research, computer systems research, and instrument calibration operations. The offices are occupied by various research scientists, engineers, and administrative personnel.

Little is known about the early use of radioactive materials in this building. Reportedly, Room 101 on the first floor was used to melt small (40-pound) depleted uranium (DU) ingots in the 1950s. A DU machine shop was located on the second floor in the area around Rooms 202, 247, and 248. The exact location is uncertain. The fifth floor contained an analytical laboratory in Rooms 501 and 512, where some DU was analyzed using wet chemical techniques and where emissions spectroscopy was performed on solutions containing DU. A 1959 Nuclear Regulatory Commission (NRC) inspection report mentions Ni-63 in an HCl solution, H-3 (tritium) in stearic acid, and Po-210 (polonium chloride) being stored in a fume hood in the isotope laboratory of Building 39. These liquids were reportedly poured down the drain to the sanitary sewer.

Recent operations involving DU include metal polishing in Rooms 145 to 147. Small DU specimens are polished with wetted abrasive paper as a first step and in an aluminum oxide slurry as a final step. Corrosion testing of DU is done in Rooms 202 and 206 with small DU specimens and small amounts of dilute salt solutions.

1.2.2.4 **Building 43**

Building 43 is a large, high-bay, one-story brick-and-steel building that was originally built in 1862. The building has undergone several renovations and additions and currently measures approximately 20,000 ft². It was originally constructed to house a blacksmith shop. Other metal-processing operations, including forging iron parts for use in seacoast gun carriages, were also performed.



In addition, the building was used for processing radioactive materials, although it was not determined when such operations were begun. The east end of the building had a concrete floor in the 1950s, but part of the floor was still dirt until the mid-1960s, when the building was used as a forge shop (MTL employee, 1992). One of the first reported uses of DU occurred in the mid-1960s, when a salt bath that was located in the southeast corner of the building was used to heat DU billets. They were extruded on the 1,000-ton press located in the northeast corner of the building (MTL employee, 1991). Whether this was done before or after the dirt floor was installed is not known. Around 1963, the melt furnace was transferred from Building 421 (in what is now the Arsenal Mall) and installed in the annex on the north side of Building 43 (MTL employee, 1992).

Recent operations included two DU melt furnaces and a heat treat furnace in the melt room located in the annex on the north side of the building. The annex contained a lathe, a mechanical saw, and a ventilation system. The main bay of Building 43, called the Forge Shop, contained a variety of mills, presses, and ovens, some of which were used primarily for processing DU. These DU machines were located at the east end of the building, and a DU incinerator was located in the southeast corner. This DU equipment was removed by Chem-Nuclear Systems, Inc. (Chem-Nuclear).

The incinerator burned DU chips and turnings. The emissions went through a scrubber and a high-efficiency particulate air (HEPA) filter and out the east end of the building. In recent times, the emissions were monitored by radiation stack monitors (MTL, 1988). The scrubber water was monitored to ensure that its concentration was less than the water effluent limits specified in 10 Code of Federal Regulations (CFR) 20 and was then poured down floor drains that discharged to the sanitary sewer (MTL, 1977).

The roof of the main bay consists of two sloped sections topped by a vee-shaped roof above a clerestory. The two sloped sections, composed of asbestos concrete, were replaced with metal panels in 1990.

1.2.2.5 **Building 60**

Building 60 was constructed in 1913 and 1914 as a central powerhouse and boiler room building. The boiler was originally coal-fired but was later converted to fuel oil. The plant produced electricity until 1919.

The building currently houses an oil-fired boiler that produces steam for heating other buildings in the installation. The steam is piped through underground steam tunnels to each building. The asbestos cement roof was recently replaced with a metal roof.

1.2.2.6 Building 97

Building 97 was constructed in 1920 and measures 56 ft by 185 ft. The building was reportedly used as a railroad locomotive repair shop. It was renovated and converted in the late 1950s to house operations associated with the nuclear reactor.



The building also contains various laboratories, male and female decontamination areas, an ion implantation facility, and a particle accelerator for neutron production.

An NRC inspection report dated 1962 indicated that radioactive by-products were being stored in the building. Liquids from the reactor and the laboratories drained to a sump in the south end of the building. The liquid was pumped to three 3,000-gallon indoor aboveground tanks. The wastewater was monitored and released to the sanitary sewer if it was determined to be below effluent limits.

A 1966 NRC inspection report discussed the Kaman neutron generator located in Room 145. This generator used 7-curie tritium targets. The neutron generator used a vacuum system to collect tritium (H-3). Air monitoring for tritium was being performed, but none was detected. The NRC inspection report also mentioned that experiments were being performed in Room 144 using microcurie amounts of 5 to 35.

Currently, portions of the Kaman neutron generator are in place, but the bulk of it has been removed. The liquid waste sump is present, but the three 3,000-gallon aboveground tanks have been removed to accommodate an accelerator. The water from the sump is pumped directly to a drain that discharges to the sanitary sewer.

1.2.2.7 Building 111

Building 111 was built in 1865. It is three stories tall, constructed of brick, and contains approximately 12,000 ft² of floor space. The building provides housing for the installation commanding officer and his family. It is listed on the National Register of Historic Places.

1.2.2.8 Buildings 117 and 118

Buildings 117 and 118 were built in 1906 and 1851, respectively. The buildings were originally constructed to house cows and horses. They were later renovated and converted to provide military housing. Building 118 was also previously used to house the post fire engine. Building 117 is currently used for military housing, and Building 118 is used for military dependent housing.

1.2.2.9 **Building 131**

Building 131, a two-story brick building with basement, was built in 1900 and expanded in 1942. It has undergone several renovations and additions and currently contains approximately 68,000 ft² of floor space.

Since its construction, the building has been used for administration. Currently, several installation administrative offices, including budget, procurement, personnel, records management, laboratory administrative offices, and technical planning offices, are located in this building. The building also contains a health clinic, mail room, and print shop.



1.2.2.10 Structure 226

Structure 226 is a concrete tank vault located at the northwest corner of Building 43, and houses two 10,000-gallon heating oil tanks. The vault is partially buried and is accessible from the surface by a bulkhead. The vault is of concrete construction. No known spills or releases are associated with this vault.

1.2.2.11 Structure 227

Structure 227 is a brick-and-concrete containment structure, housing pumping equipment and two 25,000-gallon No. 6 fuel oil tanks. Historical documents (THAMA, April 1980, and EG&G, March 1988) also list this structure as the source of the 1979 No. 6 fuel oil release to the Charles River. It is unclear from the documents which structure (227 or 295) is the true source of the release.

1.2.2.12 Structure 229

Structure 229 is a 9-ft-by-15-ft concrete building constructed in the early 1940s. It is used to house cooling oil pumping equipment. An associated 3,000-gallon underground storage tank (UST) was removed in 1991.

1.2.2.13 **Building 241**

Building 241 is a 26-ft-by-18-ft prefabricated metal building that was erected on an existing concrete slab in the early 1980s. The building is used for storing drums and barrels containing radioactive DU and beryllium waste products prior to off-site shipment.

1.2.2.14 **Building 243**

Building 243 is a 20-ft-by-30-ft brick building constructed during the 1950s. A 20-ft-by-12-ft prefabricated metal storage building was added in the 1970s. Both buildings are used for storage of various chemicals prior to use.

1.2.2.15 Structures 244 and 245

Structures 244 and 245 are propellant/explosives storage bunkers, situated side by side and enclosed within a single brick structure. The structure is located near the guardhouse in the southeast corner of the site. Currently, Building 244 is empty. An inventory of the contents of Bunker 245 is provided as part of Appendix L. It should be noted here that while Bunker 244 is empty, researchers and scientists are allowed a maximum of 5 pounds of explosives in selected areas of Buildings 311 (detonics lab), 312 (firing range), and 313 (firing ranges).



1.2.2.16 Building 246

Building 246 is a 30-ft-by-60-ft prefabricated metal building constructed during the 1970s. The building is used for storing road and grounds maintenance equipment and supplies.

1.2.2.17 **Building 292**

Building 292 is a two-story brick building constructed in 1920. It currently measures 70 ft by 215 ft. The building was originally built as a metal stock storehouse. It was also used to house a plating shop operation. The building was renovated in the late 1950s and converted to a general laboratory building.

The building currently contains several offices and laboratories. Laboratory operations performed include x-ray diffraction, electron micrography, chromatography, and analytical wet chemistry.

It is not known when DU was first used in this building. Pieces of DU material were used in various experiments or tests, and DU was analyzed by x-ray diffraction in Rooms 205 and 212. Wet chemistry analysis involving radioactive materials was also performed in Room 212.

1.2.2.18 Structure 295

Structure 295 is a large concrete containment area housing four 10,000-gallon aboveground No. 6 fuel oil tanks. In 1979, a containment wall crack and a spill of No. 6 fuel oil from the tank farm allowed a release of approximately 50 gallons of oil into the Charles River. Some oil infiltration into the tunnel near Building 60 was also noted. The crack has been repaired, and recently, soil remediation has occurred in this area (see Subsections 2.12 and 2.13 for details).

1.2.2.19 **Building 311**

Building 311, a large high-bay warehouse and machine shop with overhead cranes, is constructed of brick and steel. The first section of the building was built in 1917 for the erection of disappearing, barbette and railway carriages for guns. The building has had several additions and renovations and currently measures 180 ft by 950 ft.

The building has housed numerous manufacturing operations, including cold-working of guns and gun carriages, various machine shops, induction crucible furnaces, and other associated armaments research and manufacturing operations.

Currently, operations include various research laboratories, an industrial x-ray facility, a diatonic facility, machine shop operations, a protrusion facility, a fiber composite lab, DU storage areas, materials receiving and warehousing areas, and administrative offices.



Building 311 houses a radioactive materials storage area. Radioactive materials and other products are being stored in metal drums in a fenced-in, open-top storage area segregated into two distinct storage compartments. A DU machine shop was once located on an area covered with steel plates. This is located about 100 ft past the present location of the DU storage cage. DU is also stored in the DU vault and temporarily in the shipping area in the eastern part of the building. There are currently no machining operations performed on DU in this building.

1.2.2.20 Building 312

Building 312 is a high-bay brick-and-steel building that has three floors and was built in 1894. The building has undergone several renovations and additions and currently measures approximately 80 ft by 280 ft. It was originally built to house an erecting shop for assembling gun carriages. Additional operations performed in this building include a machine tool shop, an electroplating shop, a crystal growth laboratory, a shock wave physics laboratory, ballistics ranges, a mechanical equipment loft, several offices, and a laser laboratory. A section of the first floor of this building was previously used to house a beryllium and DU machining operation. Activities using radioactive materials in this building are believed to have begun in 1963 when the DU machine shop was transferred from Building 421. A 1965 NRC inspection report stated that DU melting and machining were being done in Building 312. It reported contamination levels of 50 to 500 dpm/100 cm² beta-gamma and 20 to 300 dpm/100 cm² alpha. The rooms that contain the DU and beryllium machine shops were constructed in 1963. Reportedly, the north part of the building continued to have a dirt floor and DU chips were stored in barrels on the floor.

Recent operations include machining DU in the south end of the first floor in the areas known as the DU and beryllium machine shops. Operations included turning, cutting, grinding, and drilling. There is also a plate shop on the first floor where DU metal was cleaned and plated. In the plate shop, small DU pieces were cleaned in buckets of nitric or hydrochloric acid or alkali. They then underwent electrochemical plating with nickel and cadmium. All work was done in an area with a concrete curb and no drain (MTL employee, 1991).

A vacuum exhaust system was installed to collect dust and particles generated by the DU and beryllium machining operations. This vacuum exhaust system is located on the third floor of Building 312 and consists of a roof stack, associated ductwork, blowers, filters, and cyclone separators.

There are currently no operations involving DU being performed in the remainder of the building. It is not known whether the firing ever took place. The DU and beryllium machining areas consist of a series of small rooms (Rooms 101 through 130) with painted plaster walls and ceilings and a concrete floor covered with asphalt tile. The rooms contain various machine tools, glove boxes, sinks, and other equipment. The plating shop is a room with a 20-ft ceiling, painted brick walls, and a concrete floor. The room contained electroplating tanks in an area with a concrete curb.



1.2.2.21 Building 313

Building 313 has two stories and a basement and was constructed in 1862 in the shape of a capital E. The building was initially used as a carriage and machine shop for gun carriage fabrication and also as a powerhouse for adjacent buildings (43 and 37). The south end of the building was also previously used as a woodworking shop. The building has had several renovations, including a second-story addition to the center wing in 1942, and currently measures 180 ft by 300 ft.

Currently, the building houses ballistics ranges, several research laboratories, and administrative offices. The south wing of the building contains an experimental foundry, a ceramic research and fabrication area, and a clean dry laboratory. The center wing contains a welding laboratory, the nondestructive examination (NDE) school, and associated NDE laboratories. The north wing of the building houses the installation security offices, general research laboratories, a ceramic laboratory, and other administrative offices. Ballistics ranges are also located in the basement of this wing.

Pieces of DU were taken to Building 313, where various experiments or tests were conducted. Ballistics testing may have been performed in the building as well. Room 150A, in the center wing, was used for DU storage. There was no other known use of DU in this building.

1.2.2.22 Structures 652 and 654

These two structures are pump houses located on the southern fence line of the facility just south of Structure 295. The construction dates of the pump houses are unknown. The structures contain equipment that was used to pump water from the Charles River for use in the fire protection system. The equipment was abandoned in place when the fire water system was converted to use the municipal water supply.

1.2.2.23 Building 656

Building 656 is a 40-ft-by-30-ft single-story brick building built during the early 1960s. It is used for storage of cooling equipment.

1.3 PREVIOUS INVESTIGATIONS

1.3.1 PRE-RI INVESTIGATIONS

Thirteen previous investigations that pertain to environmental conditions at MTL were completed between September 1968 and December 1987. These investigations, which antedate RI/FS investigations, are listed in chronological order below:

Air Pollution Status and Environmental Survey No. 44-21-0214-81, U.S.
 Army Environmental Hygiene Agency, January 1981.



- Environmental Assessment Report for Phase 1 of the AMMRC Master Plan, Camp, Dresser & McKee, Inc., May 1980.
- Environmental Compliance Audit MTL, PRC Engineering for U.S. Army Engineer Division, May 1986.
- Environmental Radiological Monitoring Plan for the Army Materials Research Reactor, Charles E. Dady and Leo F. Foley, 13 September 1968.
- Geotechnical Report, Army Materials Technology Laboratory, Watertown,
 Massachusetts, Goldberg Zoino Associates, Inc. (GZA), December 1987.
- <u>Installation Assessment of United States Army Materials and Mechanics</u> <u>Research Center</u>, Report No. 169, USATHAMA, April 1980.
- <u>Investigation of Storm Drain Pollutants</u>, Coffin and Richardson, Inc., July 1979, revised January 1982.
- <u>Plating Wastewater Pretreatment System</u>, Alonzo B. Reed, Inc. and Hoyle, Tanner & Associates, Inc., September 1978.
- Preliminary Assessment/Site Inspection for the U.S. Army Materials Technology Laboratory (PA/SI), EG&G Idaho, Inc., March 1988.
- Radiological Safety Survey, Nuclear Reactor, John F. Vining III, Acting An. Safety Officer (Internal Army Report), June 1982.
- <u>Radiological Survey of the Former Watertown Arsenal Property, GSA Site</u>, Argonne National Laboratory (ANL), October 1983.
- Wastewater Engineering Survey No. 32-61-0134-79, Department of the Army, U.S. Environmental Hygiene Agency, North Regional Division, May 1979.

A summary of findings of the reports available to WESTON is included in Table 1-1.

In 1987, AEC initiated additional environmental investigations under the Army's Installation Restoration Program (IRP). A PA/SI (EG&G, 1988) was performed as the first step of this program. The PA/SI scope of work included an assessment of previous uses of the 15 existing on-site buildings and 15 existing structures, several buildings/structures that had been razed prior to the PA/SI, and also potential contaminants associated with their previous uses, as summarized in Table 1-2.

A more comprehensive list of chemicals used and stored at MTL is presented in Appendix L. The appendix provides a listing of chemical usage in the metallurgy lab in Building 39, a chemical inventory for MTL buildings, and the hazardous waste disposal records of MTL for 1990 and 1991.



The PA/SI subdivided MTL into 18 geographical units, each of which contains a mixed assemblage of potential waste sources (Figure 1-3). The 18 units are divided in such a way that each contains a separate building or structure or group of structures (if the structures are small or have similar missions). The assessment of previous practices and uses of the on-site buildings and their associated contaminants was presented as a separate discussion for each of the 18 geographical units. The PA/SI also included a soil gas investigation to preliminarily characterize source areas.

1.3.2 PHASE 1 RI INVESTIGATION

Based on the findings of the PA/SI, a technical plan was prepared for a Phase 1 RI (EG&G, May 1988). The Phase 1 RI had four objectives:

- Determine the historical and present uses of the laboratory facilities.
- Identify and quantify the contaminants and their locations at MTL.
- Determine the sources of the contamination and the potential for environmental impacts from past and present operations.
- Address the actions necessary to prevent negative future environmental impacts.

The primary motive for selecting the type and quantity of data collected for the Phase 1 RI was the need to describe the nature and extent of contamination at MTL. The sampling and analyses were designed to characterize the hydrogeologic conditions beneath MTL and to define the spatial distribution of any contaminants that may be present (EG&G, May 1988).

A secondary objective of the Phase 1 RI sampling program was to acquire sufficient data for the development of a preliminary risk analysis for the MTL site.

The third objective of the program was to use the data collected in the preparation of an FS for the site. The data collected during Phase 1 will be used in conjunction with Phase 2 data for the development and evaluation of remedial alternatives under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

The primary target areas of the Phase 1 RI sampling effort were the subsurface soils, the groundwater, and the storm sewer/outfall system at MTL. The intent of the Phase 1 sampling was to screen the site for possible subsurface sources of contamination as well as to define possible subsurface contaminant pathways. The sampling was also intended to determine preliminarily whether water and sediment flow in the MTL storm sewer system could serve as a transport mechanism for contaminant migration to the Charles River.



The other target areas included facility buildings, utilities (polychlorinated biphenyl [PCB] transformers), and storage tanks. For these areas, the Phase 1 sampling program was designed to determine whether each area contains the types and quantities of contaminants that would present risks to human health (through direct exposure) or the environment.

In 1988, a field sampling program based on the technical plan (EG&G, 1988) was conducted by EG&G. As part of field activities, various air, dust, sediment, surface water, wipe, and surface and subsurface soil samples were collected and analyzed for various contaminants (volatile organic compounds [VOCs], base/neutral/acid extractable organic compounds [BNAs], pesticides, metals, and radiological parameters). Results of these field efforts are presented in the "Environmental Investigation Status Report" (EG&G, 1990).

Because of the development of various issues surrounding the laboratory that analyzed these samples, the results of this program were considered insupportable by AEC. Consequently, ADL was retained by EG&G to perform resampling in 1990, concurrent with the preparation of the Status Report (EG&G, September 1990). This effort was intended to repeat the original RI sampling performed in 1988; however, not all samples were repeated, and some samples were added to the 1990 sampling effort as well. Results of this field effort are presented in a report (ADL, 1990).

Results of the Phase 1 sampling effort, as well as conclusions and a preliminary RA, are presented in the Phase 1 RI (WESTON, 1991). The Phase 1 RI report was prepared primarily using the information collected during the resampling event that occurred in February 1990 (ADL, 1990). In instances where a particular sampling point or a particular sampling medium (such as air or dust) was not resampled in 1990, the 1988 results (EG&G, 1990) were used.

The RI report is developed in accordance with the following requirements, guidance, and regulations:

- Army Regulation (AR) 200-1.
- U.S. Environmental Protection Agency (EPA) Draft Guidance on Remedial Investigations and Feasibility Studies Under CERCLA (1988), as updated by SARA (1986) and the National Contingency Plan (NCP).
- Massachusetts Contingency Plan (MCP, 310 CMR 40).
- National Environmental Policy Act (NEPA), as implemented by AR 200-2.

Under these requirements, identification of the state, federal, and local applicable or relevant and appropriate requirements (ARARs) is also part of the scope of this RI, as stated in the Statement of Work (SOW). These ARARs are presented in Section 4 of this RI.



Once the nature, extent, and transport mechanism of the various contaminants at MTL have been determined (through collection of sampling data), an RA will be performed. This analysis includes evaluations of the collective demographic, geographic, physical, chemical, biological, radiological, and ecological factors associated with the contamination identified as a result of the Phase 1 and Phase 2 sampling activities at MTL. The current status of asbestos management at MTL is also evaluated.

The human health RA will be performed using assumptions and equations from the CERCLA RA Guidance in accordance with the NCP. These assumptions (regarding such variables as reference doses [RfDs] and human intake factors) are thought to be more conservative than those assumptions made in accordance with the MCP; however, once risks are calculated, they are to be compared to both MCP and NCP limits for carcinogenic and noncarcinogenic contaminants. In this way, the lower MCP limits are considered and the overall risk evaluation is more conservative.

1.4 SCOPE OF THE PHASE 2 RI

1.4.1 POTENTIAL HAZARDS ADDRESSED IN THE RI

As part of contract DAAA15-90-D-0009, WESTON has been tasked to perform a Phase 2 RI at MTL. The Phase 2 SOW issued by AEC on 29 August 1990 directed WESTON to complete the following tasks:

- Develop approved technical plans as identified by Section C.3.2.1.1.1 of the basic contract and Section 5.2 of the SOW.
- Conduct a field program implementing these plans to ultimately meet the program requirements of AR 405-90 and the Army's goal of property transfer, and to fulfill all data gaps and needs identified by the Phase 1 RI.

The Phase 2 scope of field activities is presented below:

- Storm/sanitary sewer investigation
- Inspection and survey of containers
- Geophysical investigations
- Surface and subsurface soils investigations
- Groundwater investigations
- Surface water and sediment investigations
- Radiological investigations
- Building interior wipe sampling investigations
- Air investigation
- Status report of MTL's radon program
- Removability test
- Mixed waste investigation



1.4.2 POTENTIAL HAZARDS NOT ADDRESSED IN THE RI

There are several sources of contamination at the MTL site that were not sampled as part of the Phase 2 RI fieldwork. These include radon, asbestos, lead paint, USTs, and PCB transformer oils.

1.4.2.1 Radon

Radon has been identified in several buildings at MTL. The MTL Risk Management Office currently oversees an ongoing radon-sampling program. Radon health risks at the site have been evaluated, and steps for radon remediation have already been recommended. Therefore, investigation of radon at MTL was not part of the scope of the Phase 2 RI; however, in isolated instances where not all of the sources of radiological activities in various buildings could be accounted for, radon testing was conducted. This is described further in Subsection 4.8. The MTL radon-monitoring program is described below.

AR 200-1, Chapter 11, is the Army Radon Reduction Program (ARRP). The Army has divided the testing of buildings for radon into three priorities. Priority I sites include family housing, billets, day care facilities, hospitals, and schools (24-hour occupancy). Priority II sites include training centers, operations centers, and research and development/technology facilities (24-hour operations). Priority III sites cover other facilities, office buildings, laboratories, shops, and warehouses when use is normally restricted to 8 hours or less.

The Priority I sites, the first sites to be tested, are tested for a period of 90 days, preferably under closed-up or worst-case conditions (during the fall and winter months). Structures that exceed 4 picoCuries per liter (pCi/L) but are less than 20 pCi/L are restricted for 1 year to ensure that the radon level in the structure is not artificially high.

The Priority II and III sites are not tested unless readings from the 90-day Priority I testing are >4 pCi/L, or the Priority I-measured structures geologically and structurally are not representative of the installation.

Mitigation of the structures exceeding 4 pCi/L is performed based on the magnitude of the results.

MTL performed the initial 90-day site testing by placing detectors in 72 sites at MTL in November 1989. No areas were found to contain radon above the 200 pCi/L requiring mitigation within 1 month. Three living quarters locations were found to have radon at levels above 4 pCi/L: Buildings 111, 117, and 118. Building 111 is not occupied.

Building 117 was sampled to have 32.9 pCi/L. An inspection by the Radiation Protection Officer was made and resulted in the detection of cracks in the floor and openings around incoming pipes of an underground storage heating oil tank. The



underground tank was removed and replaced with an aboveground tank. The occupants were advised to open the windows to provide ventilation.

Building 118 is an apartment unit and had radon at 10.5 pCi/L in the cellar area. This area is used as a laundry washroom. For interim remediation, fans were placed in the cellar to enhance ventilation.

MTL followed up the 90-day monitoring with long-term measurements as required by AR 200-1. Detectors were deployed in Buildings 118, 111, 131. Work for lead paint abatement was ongoing when detectors were deployed in February 1992 in Building 117; consequently, detectors were not placed in Building 117 because of the possibility of erroneous readings. Detectors were scheduled to be deployed in Building 117 for a 1-year monitoring cycle within 2 months. If the 1-year average is found to be greater than 4 pCi/L in Priority I areas, remediation is required.

Appendix S.1 provides documentation of the portion of AR 200-1 mandating the radon program at MTL.

1.4.2.2 Asbestos

MTL has been undergoing a comprehensive asbestos removal program for the past several years. Therefore, asbestos sampling was not included in the Phase 2 RI scope of work; however, monitoring the status of the asbestos program was included in the scope of work. This did not include sampling, but did include a review of asbestos sampling and removal documentation, as well as a visual inspection of areas thought to contain (or to have once contained) asbestos. During the visual inspections, asbestos was noted in several areas. This is further described in the appropriate subsections. The asbestos management program at MTL is described below.

AR 200-1, Chapter 10, Asbestos Management Program is the basis for managing asbestos at Army installations. AR 200-1 complies with EPA's Asbestos Hazard Emergency Response Act (AHERA) 1986 requirements.

MTL is following a remediation plan based on the Technical Review Committee (TRC) inspection report. The TRC report gives the priority and amounts of asbestos to be remediated for the buildings at MTL. To date, MTL has performed the following remediation.

USACE Northeast Division remediated some spray-on types of asbestos from the fourth floor of Building 39. Some work was also performed in Buildings 36, 39, 60, and 131 and is ongoing in 311. Some debris in crawl spaces needed to be removed from the housing units, but the installation has no "housing funds." MTL has sealed off the areas requiring asbestos remediation in the housing units. Building 118 is the multiple-apartment unit, and Building 117 is also a military housing unit. The commander's quarters (Building 111) has some asbestos in a steam line that services the building and needs to be remediated.



The tank farm (Building 295) has steam tunnel lines running from Building 60, which require some asbestos remediation. The work was identified by Universal Engineers, who did a survey for MTL.

Also, the transite roof on Building 60 was removed before the TRC survey.

MTL has removed some asbestos from the southeast tunnel that runs to Building 43 from a spur off a manhole near Building 37 (approximately 60 ft).

Appendix S.2 contains an inventory of asbestos in MTL buildings. A checkmark indicates asbestos that has been removed.

1.4.2.3 <u>Lead-Based Paint</u>

A Phase 2 sampling program targeting lead-based paint at MTL was not conducted, since MTL already has a lead-based paint management program. This program is described below.

The MTL lead-based paint management program is conducted in accordance with the U.S. Department of Housing and Urban Development (HUD) guidelines for lead-based paint protection. HUD guidelines are not regulations; however, when federal funding is used to remediate a site, remediation is to meet the HUD guidelines. In February 1991, MTL contracted with Lead Busters Inc., of Boston, Massachusetts, to perform a lead-based paint inspection of occupied housing. Documentation of this inspection is presented in Appendix S.3. Occupied housing at MTL consists of two buildings, Buildings 117 and 118. Building 118 is an apartment unit that provides housing for enlisted personnel. No children are living in Building 118. Building 117 is a single-family housing unit, and the family does have children.

Results found lead-based paint in both units. Funds were requested; however, at a closing installation, this type of funding is not a priority if other means can be used to protect human health. In this case, occupants in Building 117 were advised how to manage any hazards from the lead-based paint in the unit by wet mopping and washing walls rather than dusting.

Massachusetts has a mandatory property transfer notification for property owners attempting to sell residential property. Commercial property is not included in the Massachusetts regulation. The state law required the seller to file the Property Transfer Notification (PTN) 10 days prior to the sale. The PTN notifies the prospective buyer of the responsibilities for the property if it is to be used for housing children, and it allows the prospective buyer to perform a lead inspection of the building's painted surfaces at the buyer's cost.

For base closures sites, the Army will ascertain whether buildings on a site are old enough to have been painted with paint containing lead. Manufacturers began taking lead out of paint in 1973; however, the Army's inventory probably contained lead paint for a few years after that. Therefore, any buildings painted prior to 1980 are assumed



to contain paint with lead. For BC purposes, the Army discloses to the prospective buyer the likelihood of buildings containing lead paint. At MTL, it is likely that all the buildings contain some lead-based paint.

In the firing range located in the basement in Building 313, lead abatement was performed by MTL facilities for lead released from small arms testing. The remediation technique was vacuuming. Also, the USACE Northeast Division performed remediation of a ventilation system in the firing range.

In addition to the Army program described above, nearly all of the Phase 2 chemical wipe samples collected were analyzed for Target Analyte List (TAL) metals, which include lead. As a result, information on the removable portion of lead contamination on interior surfaces is available.

1.4.2.4 PCB Transformers

While some wipe samples and surface soil samples on or around selected transformers were collected and analyzed for PCBs, none of the actual transformer oils was sampled as part of the Phase 2 RI. Several on-site transformers are known to contain PCB-contaminated oils. Currently, plans exist for removing or retrofitting these transformers. Since those transformers containing PCBs were already identified, sampling of transformer oils was not included in the Phase 2 RI scope of work; however, MTL has initiated a program for retrofitting or removing transformers at the site. Appendix S.4 contains a transformer inventory for the site, which indicates those transformers that have been (or will be) retrofitted.

1.4.2.5 USTs

At the start of the Phase 2 RI, six USTs were known to exist on-site. As of the writing of this document, all six have been removed and the areas remediated and backfilled. While the RI scope of work included an attempt at locating a seventh UST using geophysical techniques, no other UST investigations were included in the Phase 2 scope of work. The field effort for locating the seventh UST is discussed in detail in Subsection 2.2.2 and findings are discussed in Subsection 4.2.1.

Several other oil storage tanks, which are not considered USTs, do exist at MTL. These include tanks in Buildings 226 and 227. Remedial efforts pertaining to a leak from a line leading into 227 are described in Subsection 2.12. Sampling was not conducted within Building 226 because of access problems; however, the inside of the building was inspected and surface soil samples were collected in the vicinity of the building. While no environmental concerns associated with the building were noted, the inside of the building was cluttered and staining on the floor was noted. This building, while not evaluated as a potential hazard in this RI, should be cleaned prior to transfer of the property.



1.5 REPORT ORGANIZATION

This document is structured as follows:

- <u>Section 1, Introduction</u>, presents the background project description, discussions of previous investigations, and a brief overview of the Phase 2 RI scope of work.
- <u>Section 2, Field Investigation Approach and Procedures,</u> presents the various field investigations performed and includes sampling objectives, field monitoring and sampling methodologies, number of samples collected, and analyses performed.
- <u>Section 3, Physical Characterization</u>, describes the physical setting of MTL and the surrounding area (including topography, land use, climate, surface hydrology, and hydrogeology) and the physical tests performed at the site (including slug testing).
- <u>Section 4, Nature and Extent of Contamination</u>, discusses ARARs for the Phase 2 RI and presents results for the physical testing and chemical sampling performed during Phase 2.
- <u>Section 5, Contaminant Fate and Transport</u>, enumerates chemicals of potential concern and discusses contaminant migration pathways and transformations.
- <u>Section 6, Baseline Risk Assessment of Human Health Effects</u>, presents a human health evaluation of the risks associated with the contaminants of potential concern, as determined from Phase 2 sampling results.
- <u>Section 7, Environmental Evaluation</u>, presents an evaluation of risks to the environment associated with the contaminants of potential concern, as determined from Phase 2 sampling results. The Environmental Evaluation will follow under a separate cover.
- <u>Section 8, Conclusions and Recommendations</u>, summarizes the results of the Phase 2 investigations and presents remedial action alternatives for MTL.
- <u>Section 9, References</u>, lists the references used in preparing this document.

Section 2 Field Investigation Approach and Procedures



FIELD INVESTIGATION APPROACH AND PROCEDURES

2.1 FIELD INVESTIGATION SUMMARY

2.1.1 DATA QUALITY OBJECTIVES

2.1.1.1 Project Data Quality Objectives

The main objective of the Phase 2 sampling program at MTL was to supply information for decisionmaking regarding the cleanup methodologies to be used in preparation for BC and release of the property for unrestricted future use. To ensure that the data collected would be adequate for these purposes, the Technical Sampling Plan (TSP) (WESTON, May 1991) was developed under guidelines set by CERCLA, although MTL is not a National Priorities List (NPL) site. Specifically, the sampling data were used for:

- Location of existing (and former) contaminant sources.
- Characterization of extent of contamination in the various environmental media at the site.
- Characterization of contamination associated with various indoor areas, containers, and sewers.
- Determination of the impact(s) of past and present MTL activities on the surrounding area.
- Determination of human health risks associated with the various contaminants on the site.

The investigations conducted to satisfy the above data objectives included the following:

- Geophysical surveys
- Subsurface soils sampling
- Groundwater sampling
- Surface soils sampling
- Charles River water and sediment sampling
- Storm sewer sampling
- Radiological surveys
- Indoor surface chemical wipe sampling
- Indoor air sampling
- Cistern, tank, sump, and dry well sampling
- Archaeological investigation



In addition, radiological survey results from the Phase 2 RI are to be used in decisions pertaining to the decommissioning of the facility. As such, radiological sampling strategies were based primarily on NRC guidelines and Massachusetts Department of Public Health (DPH) guidelines. Specifically, the radiological component of the Phase 2 sampling was to be used for:

- Identification of buildings and grounds requiring cleanup prior to decommissioning.
- Identification of areas that require no further action prior to decommissioning.
- Analysis of existing human health and ecological risks associated with the radioactivity currently at and around the facility (i.e., in the Charles River, etc.).
- Determination of cleanup measures required for decommissioning of the facility under NRC and DPH guidelines, as well as for release of the property for unrestricted use under CERCLA.

More detailed descriptions of the various field investigations, including radiological surveying, are provided in Subsections 2.2 through 2.15.

2.1.1.2 <u>Laboratory Data Quality Objectives</u>

The main objective of the analytical portion of the RI program was to ensure accurate, well-documented, defensible data. This was an especially difficult task because a large amount of data was generated in a short time and several laboratories were concurrently involved in sample analysis for the Phase 2 RI. To achieve the desired goals, a number of protocols were observed:

- Where possible, AEC-certified analytical procedures were used to analyze
 the various sample media for the constituents specified in the TSP. In
 instances where no AEC-certified method existed, EPA, NRC, or other
 generally accepted methods were used.
- An extensive data quality assurance/quality control (QA/QC) plan was developed and implemented to provide for thorough data tracking and validation. The procedures used included completion of chain-of-custody forms in the field for inclusion with each shipment of samples; performance of various QA/QC analyses for the various media sampled; performance of laboratory QC checks, such as group checks on the data on a lot-by-lot basis; completion of map-coding forms for each sample collected for entry into the Installation Restoration Data Management Information System (IRDMIS) database system; tracking of the status of the IRDMIS through periodic production of data inventories; constant communication among project management, the WESTON analytical



quality assurance coordinator (AQAC), the field team leader, and the laboratory quality assurance coordinators (LQACs) at each of the subcontracted laboratories.

A data management team was maintained that could, through periodic checking of data inventories and other database parameters, keep various project team members apprised of the status of the MTL database. This same team was able to manipulate the data into useful, tabular forms and ensure that the database was complete.

To ensure that the proper procedures were followed, constant communication among AEC representatives, WESTON personnel, and the laboratories was maintained.

Those Phase 2 data acquired using AEC-approved analytical methods are AEC Level 3 data. This data level is analogous to EPA analytical Level IV, which means the data can be used for RAs, potentially responsible party (PRP) determination, evaluation of remedial alternatives, and engineering design (EPA, 1988). EPA Level IV typically employs analytical methods that can achieve reporting limits in the low parts per billion (ppb) for most organic and inorganic parameters. Data that were not analyzed using AEC-approved methods were validated using methods similar to EPA methods and were then entered into IRDMIS by WESTON personnel.

Elevation of data to AEC Level 3 took 90 days in instances where no problems were encountered. Data acquired by AEC methods could not be evaluated for purposes of characterization, RA, or development and evaluation of remediation alternatives until Level 3 had been achieved. Other data could be evaluated immediately upon receipt by WESTON.

A discussion of the results of QA/QC sample analyses is presented in Subsection 4.12. In general, duplicate sample results compared well with the original sample results for groundwater, surface water, and soils, but less well for sediments and wipes. The field blank sampling indicated that no gross contamination was introduced into the samples by the field sampling team. No compounds were omitted from the risk assessment based on detection in blank samples.

2.1.2 FIELD INVESTIGATION SUMMARY

During the Phase 2 field characterization, samples were collected of the subsurface soil, surface soil, groundwater, storm sewer system, facility containers (i.e., cisterns, tanks, sumps, and dry wells), indoor surfaces, and indoor air at the facility, as well as of the surface water and sediment in the nearby portion of the Charles River.

Initially, a geophysical survey was conducted to identify suspected USTs on-site, to delineate fill areas along the southern border of the facility as well as off-site, and to trace certain storm and sanitary sewer lines of particular interest due to incomplete existing information. These items were investigated using ground-penetrating radar (GPR) and electromagnetic (EM) surveys, as described in Subsection 2.2.



To supplement existing subsurface information, soil borings were drilled at various locations around the facility (both on-site and off-site). The soil boring program is discussed in detail in Subsection 2.3. Some of the locations were purposely chosen to confirm or eliminate certain buildings, sewer lines, processes, etc., as contamination sources. Some of the locations were chosen to augment existing downslope "perimeter" information. Others were chosen to provide background information. Finally, some locations were chosen simply to ensure that any potential isolated points of contamination that may not be directly attributable to any single source were not missed. In all, 62 soil borings were completed.

Groundwater monitor wells were installed in a number of the Phase 2 boreholes to supplement the existing Phase 1 groundwater data. Well installation and groundwater sampling are discussed in detail in Subsection 2.4. Both Phase 1 and Phase 2 wells were sampled during the Phase 2 field program. The new well locations were chosen with the following objectives:

- Contamination previously detected in Phase 1 could be traced to possible sources.
- Any existing contaminant plumes could be identified.
- Information on both vertical and horizontal gradients could be supplemented.
- Deep groundwater quality could be characterized.
- Upgradient information could be obtained for both shallow and deep groundwater.
- Data gaps concerning the direction of groundwater flow beneath MTL and groundwater quality at the downgradient perimeter of the facility could be filled.

In all, 15 new wells were installed. The locations of the 15 new wells were surveyed by a Massachusetts registered surveyor. A total of 31 wells were sampled. In general, the samples were analyzed for Target Compound List (TCL) volatile organics, TAL metals, cyanide, PCBs, and radiological parameters. Certain wells were also sampled for nitrates and explosives. Slug tests were conducted at selected wells to estimate aquifer conductivity. Testing was conducted on four well clusters, and groundwater levels were measured in all 31 of the monitor wells.

Soil borings were advanced to determine the radiochemical constituents of the subsurface at MTL. In addition, boring lithologies were recorded for use in defining subsurface stratigraphy at the site. At each of the 62 soil borings drilled, a soil sample was collected at the surface as well as at depth (see Subsection 2.3). In addition, 30 surface soil samples not associated with the soil boring program were collected as either discrete or composite grab samples, using a stainless steel bowl and trowel as the



collection device. These samples were intended to provide source-specific information regarding surficial contamination at various locations throughout the site. The choice of analyses performed on each sample was therefore based on the location of the particular sample. A summary of these samples is presented in Subsection 2.5.

The primary objective of the Charles River sampling was to determine the impacts (if any) of MTL activities (past and present) on river quality. Surface water and sediment samples were collected from a number of locations in the Charles River to characterize conditions in the river water and the riverbed. Sample analysis results were also to be used in drawing some conclusions (primarily qualitative) about the impacts of past and present activities of MTL, as well as of other industrial sources in the vicinity, on conditions in the river. Results were also to be used in assessing the potential risks to human and/or ecological receptors through contact with the river or the outfalls from the facility. Surface water samples were collected from the river in areas upstream of. adjacent to, and downstream of the facility. These samples were collected from the main stream of the river as well as along the shoreline near MTL outfalls. Sediment samples were collected at the same locations as the surface water samples and also in several additional locations that are either in or immediately adjacent to MTL storm sewer outfalls. In all, 14 surface water and 29 sediment samples were collected during the Charles River sampling program. All of the samples were analyzed for TAL metals, TCL organics, pesticides, PCBs, gross alpha, gross beta, and isotopic uranium. In addition, selected samples were analyzed for total organic carbon (TOC), hardness, and hexavalent chromium. Sampling methods and specific sample location information are provided in Subsection 2.6.

In addition to the river samples, surface water samples were collected from seven storm sewer manholes. Storm sewer manholes were inspected and sampled to determine the possible impacts of MTL on the Charles River from discharge of facility overland flow through several storm sewer outfalls into the river. The samples included two samples from manholes located at storm sewer junctions just prior to entry of the storm sewer lines onto the site. The remaining five samples were collected from manholes just upstream (in the sewer lines) of the outfalls to the river, whose sediments were sampled as part of the river sampling program. Samples were collected as 24-hour composites during a rain event. All of the samples were analyzed for TAL metals, TCL organics, pesticides, PCBs, hardness, gross alpha, gross beta, and isotopic uranium. In addition, selected samples were analyzed for cyanide. Flow measurements were taken at each manhole at designated intervals; these measurements were intended for use in estimating the total contribution of the MTL storm sewer system to the river during a typical rain event. Storm and sanitary sewers were inspected using a video camera along key portions to determine their integrity. Sampling methods and details of the flow calculations and video inspection are presented in Subsection 2.7.

A radiological survey program was conducted to characterize the extent of radiological contamination at the site. The data gathered were intended for use in a facility decontamination and decommissioning plan for buildings currently under NRC licenses



and also to support the release of buildings not suspected of radiological contamination for unrestricted use. The survey consisted of the following main elements:

- A background survey (indoors and outdoors) to determine natural background radiation levels in the area.
- An outdoor survey involving the recording of instrumental readings obtained during an outdoor site walkover with an NaI Gamma Field Instrument for Detection of Low-Energy Radiation (FIDLER) detector.
- An indoor survey involving building walk-throughs with portable radiation detectors combined with a wipe sampling program of interior (permanent) surfaces, such as walls, floors, French drains, drain traps, sumps, and I beams. The indoor survey also involved a removability study to determine which decontamination techniques would be necessary to reduce indoor contamination to background levels.
- Analysis of samples collected under the other programs described in this section for various radiological parameters, generally gross alpha/beta and isotopic uranium, but occasionally other parameters as well.
- Miscellaneous surveys, including gamma logging of boreholes drilled as part of the subsurface soils investigation, a building roof and rafters survey, a survey of the steam tunnels underlying the facility, an investigation of selected building sanitary drainlines and sanitary sewer manholes, and a limited survey of ductwork at the facility.

Throughout the survey, those buildings or areas not suspected of radiological contamination were sampled with the greatest frequency, since it is the intent of the study to meet the NRC's requirements for release of the buildings for unrestricted use. The intent of the survey of buildings/areas suspected of contamination was to provide information that will be used in the selection of remediation and disposal alternatives. Since this survey was not intended as a final survey, samples were collected at a lesser frequency. Survey and sampling techniques, analyses, and rationales are described in detail in Subsection 2.8.

As part of the Phase 2 characterization of MTL buildings, an extensive chemical wipe sampling program was conducted at the site. Wipe samples were collected in 17 on-site buildings/structures and 4 off-site buildings (background). Wipe sample analyses depended on the past (if known) and present activities conducted in each building (and each individual room) wiped. Generally, TCL semivolatiles and metals were analyzed. Other parameters analyzed were nitrates, cyanide, explosives, pesticides, and PCBs. A total of 855 indoor locations were wiped. The chemical wipe program is described in more detail in Subsection 2.9.

From those buildings and structures whose histories indicated the possibility of air contamination and whose structures indicated the possibility of future human



habitation, 24-hour composite air samples were collected. Outdoor ambient air samples were collected from several locations to provide adequate background information. Thirteen building interiors were sampled. Twenty-four indoor locations were sampled, and background samples were acquired from three outdoor locations on-site. The choice of analyses requested for each building sampled was based on the past and present activities conducted within each building. The full gambit of analyses was run on each of the background samples. This includes TCL organics, TAL metals, cyanide, explosives, nitrates, PCBs, gross alpha/beta, and isotopic uranium. The sampling methods as well as the analyses requested for each building are described in Subsection 2.10.

During a site walk-through in Phase 2, a number of cisterns, tanks, sumps, and dry wells were discovered and visually inspected. Where sufficient material was available, liquid and/or sediment samples were collected from these containers. As with various other Phase 2 programs (described above), the analyses requested for each of these containers were largely dependent on the past and present uses of the buildings or structures these containers were in or adjacent to; however, where possible, each container was analyzed for at least TCL organics, TAL metals, cyanide, pesticides, PCBs, gross alpha/beta, and isotopic uranium. In some instances, other radioisotopes, such as thorium-230 (Th-230) and cesium-137 (Cs-137), were analyzed. A total of 25 containers, both indoor and outdoor, were sampled. Details of the sampling are provided in Subsection 2.11.

Throughout the Phase 2 investigations, care was taken to maintain the structural and historical integrity of the buildings at the facility. Prior to commencement of field activities, the Massachusetts State Historic Preservation Officer (SHPO) was given an opportunity to review the Phase 2 TSP and concurred with its contents. In addition, the field activities were conducted in accordance with the Memorandum of Agreement (MOA) between the Army, the Massachusetts Advisory Council on Historic Preservation, and the SHPO concerning the closure and disposal of MTL.

In addition, a licensed archaeologist was present for all intrusive subsurface activities, i.e., soil borings. The archaeologist logged each WESTON boring and collected and catalogued any artifacts encountered during drilling. Results of the archaeological findings are presented in Subsection 2.15.

2.2 GEOPHYSICAL SURVEYS

The geophysical investigation at MTL was designed to answer specific questions about certain areas on- and off-site. GPR was the primary geophysical survey method, but noncontacting EM terrain conductivity was used in certain locations.

2.2.1 INSTRUMENTATION AND THEORY

The GPR survey was conducted using a Geophysical Survey System, Inc. (GSSI) Model SIR System 8 GPR coupled to a Model 3105 AP 300-MHz antenna. The System 8 unit consists of a Model 4800 radar control unit, a Model 5P-100 microcomputer, a Model



SR-8004H graphic recorder, a Model P731 calibrator, and a 200-ft transducer cable. The 12-volt battery from the field vehicle was used to power the radar system.

GPR is a surface interface radar (SIR) system that transmits an EM pulse into the subsurface. The pulse travels through the subsurface until it encounters a soil interface or emplaced object with contrasting dielectrical properties. This contrast causes a portion of the transmitted pulse to be reflected back toward the surface. The reflected energy is received by the antenna and is transmitted to the control unit. The reflected EM pulse is processed in the control unit and transmitted to both the oscilloscope and the graphic recorder. The graphic recorder produces a hard-copy subsurface profile that can be analyzed in the field or office.

The depth of GPR penetration varies from site to site and is reduced in soils with relatively high conductivity (i.e., clay-rich soils). In an area with predominantly clay soils, GPR penetration may be only 3 to 5 ft or less; signal attenuation would prohibit detection of deeper soil horizons and buried objects. Identification of a subsurface feature also depends on its dielectric contrast with surrounding features. Consequently, not every subsurface feature can be identified using a GPR survey.

The EM survey was conducted with a Geonics, Ltd. EM-31D Noncontacting Terrain Conductivity Meter (EM-31). The EM-31 is battery-powered and operates at a frequency of 9.8 kHz. The system consists of a transmitting coil, receiving coil, phase-sensing circuits, and an amplifier. A fixed 3.7-meter intercoil spacing is standard for the EM-31.

The EM-31 operates by creating an alternating primary magnetic field at the transmitting coil. This primary field is produced by alternating current in the transmitting coil at an audio frequency. An electromotive force is produced in the earth by the primary field, which causes secondary loops of electrical current to flow in the subsurface. This process is known as EM induction. An alternating secondary magnetic field results from this current flow in the earth. The receiving coil responds to an electromotive force generated by the resultant of the primary and secondary fields.

Both the quadrature and in-phase components of the secondary alternating field will be measured at the site. The quadrature component is sensitive to conductors with low induction numbers (i.e., low-conductivity materials). A linear relationship exists between conductivity and the ratio of the secondary field quadrature component to the primary field at low induction numbers. At high conductivity, the quadrature component departs from linearity, becoming negative. The in-phase component has a greater sensitivity to buried metal objects. Apparent conductivity values associated with in-phase measurements have no absolute meaning. It is more appropriate to consider them as ratios of the in-phase EM fields. Negative in-phase (and quadrature) conductivity values may be observed at the site. This phenomenon occurs as a result of the transmitting and receiving coils straddling a metallic conductor (e.g., surface debris or buried metal). Conductivity decreases to a negative minimum as a result of the geometry of the system. The conductivity again returns to that of the normal soil



or rock (background) once out of the influence of the metallic object. Conductivity measurements were obtained in the vertical dipole mode of operation. The effective depth of exploration associated with this mode of operation is 18 ft.

The EM-31 instrument measures apparent conductivity in units of millimhos per meter (mmhos/m) in materials with true conductivities ranging up to 1,000 mmhos/m. Apparent conductivity is not the true conductivity of a material. Rather, it is an average value that is derived from the heterogeneity and anisotropy present in the subsurface under most conditions.

2.2.2 IDENTIFICATION OF USTs

The purpose of the GPR survey in the parking lot between Buildings 37 and 131 was to search for a suspected UST.

Prior to conducting the GPR survey, a grid was laid out covering the two islands at the east end of the parking lot. The existing parking space divider lines were used as the grid in the paved areas. The GPR record length was set to 100 nanoseconds (ns), and the system was calibrated to on-site soil and moisture conditions by making several traverses with the antenna over the survey area. GPR traverses on the two islands were conducted at 5-ft intervals in both north-south and east-west directions. East-west traverses on the pavement were conducted at 4- to 6-ft intervals. North-south traverses were also completed on the pavement in disturbed areas. The EM-31 was then used to determine if there was metal in the disturbed areas.

2.2.3 FILL AREAS

Geophysical techniques were employed to locate potentially contaminated areas of fill in three separate areas. GPR was the primary screening tool used to investigate the park between North Beacon Street and the Charles River. GPR was also used to investigate the area north of North Beacon Street and south of the embankment in the southeast corner of the MTL facility. Finally, the areas south and west of Building 60 were investigated with the GPR to explore reports of an ash disposal pit.

Before beginning the GPR survey in each area, a ground reference grid was established. In the park, the intersection of the bridge and the south edge of the sidewalk were used as the reference grid origin. Pin flags and a tape measure were used to subdivide the park at 50-ft intervals. Each flag was labeled with appropriate grid coordinates. These pin flags were replaced by wooden grade stakes in areas covered by the EM survey. All pin flags and grade stakes were removed after completion of the survey.

North of North Beacon Street, pin flags were placed at 50-ft intervals along the iron fence to serve as reference points. Spray paint was used to mark the pavement for the reference grid near Building 60.

In each area, the record-length electronic gains and filters were adjusted to optimize subsurface resolution before beginning the GPR survey. GPR traverses were conducted



at 10-ft intervals both parallel and perpendicular to North Beacon Street in the park and south of the embankment. Near Building 60, GPR traverses were made at 5-ft intervals parallel to the building walls. All GPR data were printed as hard-copy profiles as the survey progressed. Periodically, a traverse was repeated to ensure that variations observed resulted from changing subsurface conditions rather than aberrations in system electronics.

2.2.4 STORM/SANITARY SEWER LINES

The objectives of the storm/sanitary sewer line geophysical investigation were to locate two stormwater outfalls to the Charles River and to resolve discrepancies between site maps and diagrams drawn by an ADL sampling team.

GPR was used to trace the outfalls. Visual inspection was the primary tool used to resolve discrepancies between the site maps and previous sampling diagrams. If the discrepancies could not be resolved visually, GPR was used. In both the outfall and junction surveys, GPR traverses were conducted perpendicular to the buried pipes.

2.3 SUBSURFACE SOIL INVESTIGATION

2.3.1 OBJECTIVES

The objectives of the soil boring program were to determine the impact of potential contaminant sources on the subsurface soils and to provide additional information on composition and thickness of unconsolidated materials at MTL. The subsurface soil survey was designed to investigate potential soil contamination in the following areas:

- Where groundwater contamination was previously detected (e.g., MW-8 and C-2).
- Near areas where chemicals and radioisotopes have been used or previously detected.
- Across the facility on a grid pattern to provide sitewide sampling coverage.
- Upgradient of the facility.

2.3.2 BOREHOLE DRILLING

The subsurface soil investigation involved completing 62 soil borings between 15 October and 15 November 1991. Soil borings were completed with a Davey-Kent truck-mounted drill rig using 4.5-inch hollow-stem soil augers. A primary objective of the soil boring program was to identify contaminants at the locations identified above. To



complete this objective, soil borings and sample collection were completed in four primary locations, as follows:

- Along the northern perimeter and north of the site, to determine soil quality upgradient of the site.
- On the facility, concentrated around potential contamination sources.
- South of the facility, between North Beacon Street and the Charles River, to identify contamination associated with soil fill.
- In a grid system involving 24 borings that were drilled to detect potential contamination resulting from site activities that may not have been reported.

Soil samples were collected using a 2-ft-by-1.375-inch stainless steel, split-spoon sampler. Standard penetration tests were completed on each sample by recording the number of blows required to drive the sampler through 2 ft of undisturbed soil. The sampler was driven using a 140-pound hammer falling 30 inches.

Continuous sampling was typically completed in each boring from ground surface through the top of the water table, except where borings were terminated above the water table because of auger refusal or contact with unidentified buried objects. Split-spoon samples were collected from beneath the water table only in borings where installation of monitor wells was planned. All other borings were terminated at or above the water table. In borings where installation of a monitor well was planned, split-spoon soil samples were collected at 5-ft intervals from immediately beneath the water table to the bottom of the boring.

Original plans called for completion of nine soil borings within buildings; however, two borings were abandoned, leaving a total of seven completed indoor borings. Borings were begun by first coring through concrete floors with a 6-inch coring barrel. In buildings with adequate working area, the truck-mounted auger rig was then used for soil boring. In buildings without adequate work space, a portable, skid-mounted, hollow-stem auger rig was used. The maximum depth achieved by the portable rig was approximately 10 ft.

2.3.3 SAMPLING

Lithologic classification of all soil samples was conducted in the field using the Unified Soil Classification System (USCS), and each sample was also field-screened for elevated VOCs and gamma radiation. Soil boring logs, developed based on lithologic and field screening results, are presented in Appendix A. Representative lithologic samples were collected from each spoon and stored in 8-ounce glass containers. Between two and six soil samples were collected from each soil boring and submitted for laboratory analysis. Each soil sample submitted to the laboratory was analyzed for the following parameters: TCL organics; cyanide; TAL metals; and radioactive parameters, including



alpha and beta, U-234, U-235, and U-238. In addition, selected soil samples were analyzed for TOC.

2.4 GROUNDWATER INVESTIGATION

2.4.1 OBJECTIVE

As part of the Phase 2 RI field program, WESTON completed a groundwater investigation between October and December 1991. A previous groundwater investigation involving installation and sampling of 16 monitor wells was completed between May 1988 and February 1990 as part of the Phase 1 RI. The Phase 2 RI groundwater investigation was performed to address uncertainties that were identified following completion of Phase 1 work. The objectives of the groundwater program were as follows:

- To further delineate groundwater contamination plumes previously identified at the MTL site and to identify any additional areas of contamination.
- To increase understanding of hydrogeologic factors influencing groundwater flow and contaminant transport.
- To obtain groundwater-quality data to be used in developing the baseline risk assessment.
- To accurately characterize chemistry of groundwater flowing onto the MTL site (upgradient conditions).

To the extent possible, existing data and monitor wells from the previous investigation were used; however, 15 additional monitor wells were installed, and additional hydrogeologic and water quality data were collected.

Fieldwork performed for the Phase 2 groundwater investigation falls within one of the following categories:

- Installation of additional groundwater monitor wells
- Determination of groundwater flow direction and hydraulic gradients
- Performance of groundwater sampling
- Assessment of aquifer hydraulic conductivity

A detailed discussion of each component of the groundwater investigation is provided below.



2.4.2 MONITOR WELL INSTALLATION AND DEVELOPMENT

2.4.2.1 Overview

Between 8 October and 9 December 1991, 15 monitor wells were installed and developed under the direction of on-site geologists from WESTON. During the Phase 1 study, 16 monitor wells had been installed at the MTL site.

Of the 15 wells installed during the Phase 2 study, 5 wells were installed upgradient of the site to characterize quality of groundwater flowing onto the site, 4 wells were installed at the downgradient boundary to better characterize the quality of groundwater migrating off the site, and the remainder of the wells were installed within the site to identify and further delineate on-site groundwater contamination. Nine of the new wells were constructed with screens placed across the water table to detect possible dissolved and floating free-phase contaminants. The six remaining wells were drilled to refusal to check for dense free-phase contaminants that could potentially accumulate at hydraulic conductivity barriers, such as the bedrock interface. Eight of the new wells were installed as well couplets (four locations) to provide information on vertical variations in hydraulic gradient, hydraulic conductivity, and groundwater chemistry. Well construction details are summarized for all new and existing wells in Section 3, and a well construction log is provided for each new well in Appendix B. All wells have been constructed with 4-inch schedule 40 polyvinyl chloride (PVC), each with a 10-ft screened section. All wells have been fitted with a 6-inch locking pressure cap and a 12-inch, flush-mounted waterproof protective cover.

While wells were being drilled, split-spoon samples were collected for lithographic classification using the USCS. Selected soil samples were submitted for chemical analysis. Further details of the Phase 2 RI subsurface soil investigation are provided in Subsection 2.3 of this report.

As mentioned, each new monitor well was installed to fill data gaps identified following completion of the Phase 1 RI. A justification for each well location is provided below:

- Well cluster MW-15/MW-15A is located south of and immediately adjacent to Building 311. Building 311 is approximately 300 yards long and houses a number of machining, laboratory, and testing activities, and MW-15 was installed to characterize shallow groundwater (water table) quality immediately downgradient of Building 311. MW-15A, located approximately 10 ft west of MW-15, was installed to characterize deep groundwater downgradient of Building 311. MW-15A was drilled to refusal. The well couplet MW-15/MW-15A also provides information on vertical hydraulic gradient and vertical variations in hydraulic conductivity at this location.
- Original plans called for well cluster MW-16/MW-16A to be located in the northeastern corner of the site near Building 43 to provide information on upgradient groundwater quality; however, the planned well locations



were relocated approximately 180 ft north of the site to the opposite (north) side of Arsenal Street to provide information on groundwater quality further upgradient. MW-16A is located approximately 10 ft west of MW-16 and provides upgradient groundwater chemical data for deeper strata. The paired wells MW-16 and MW-16A were also used to provide information on vertical hydraulic gradients and vertical variations in hydraulic conductivity at this location.

- Well cluster MW-17/MW-17A is located approximately 150 ft south (downgradient) of the deactivated nuclear reactor (Structure 100) and was installed to characterize groundwater quality downslope of the reactor. MW-17 was constructed with the well screen intersecting the water table. MW-17A is located approximately 10 ft east of MW-17. This well is used to characterize the deep groundwater quality downgradient of the deactivated reactor. MW-17A was drilled to auger refusal. The well cluster MW-17/MW-17A also provides additional information on vertical hydraulic gradients and vertical variations in hydraulic conductivity at this location.
- MW-18 is located adjacent to and downslope of the concrete-lined loading areas and tank farm (containing four aboveground fuel oil storage tanks), approximately 50 ft from the southeastern property boundary. This well has been used to assess the impacts of the fuel loading area and fuel storage tanks on the shallow aquifer and to better characterize off-site migration of groundwater. MW-18 was drilled to intersect the water table, with the bottom of the screen set at 24.5 ft below ground surface (bgs).
- Well cluster MW-19/MW-19A/MW-19B is located approximately 100 ft southeast of Building 131. Toluene and related compounds were detected in well C-2; well cluster MW-19 was installed to characterize the extent of contamination detected in well C-2. The well screen for MW-19 was placed across the water table. MW-19B is located approximately 20 ft west of MW-19. Originally, installation of MW-19B was not proposed; however, on the first attempt at drilling MW-19A, hollow-stem augers encountered refusal at 54 ft bgs. Rather than abandon the well altogether, it was decided, following a conversation with officials from AEC, that a well installed at the till/sand interface would be useful. Therefore, MW-19B was installed to characterize groundwater at this depth. MW-19A was installed to characterize groundwater at the glacial till/bedrock interface. Well cluster MW-19/MW-19A/MW-19B also provides information on vertical hydraulic gradients and vertical variations in hydraulic conductivity.
- MW-20 is a deep well located approximately 20 ft south of the previously installed shallow well MW-8. MW-20 was installed to determine whether any of the dense, aqueous-phase contaminants previously found in shallow



well MW-8 have migrated into deeper strata. Water-level measurements from MW-20 and MW-8 also provide information on the vertical hydraulic gradient beneath the eastern edge of the site.

- MW-21 is a deep well located along the southern property line between MW-1 and MW-2, approximately 150 ft south of Building 39. MW-21 was installed to determine the quality of deep groundwater flowing off-site beneath the southwest portion of the site.
- MW-22, MW-23, and MW-24 were installed north of the MTL site to establish upgradient groundwater quality conditions for groundwater flowing onto the MTL site. All three wells were screened across the water table.

The new wells will also provide additional detail on groundwater flow in and around the site and will allow for construction of more precise water table maps than were possible using only the 16 Phase 1 monitor wells.

2.4.2.2 Monitor Well Drilling Program

The Phase 2 drilling program began on 8 October 1991 and ended on 9 December 1991. During this interval, 15 groundwater monitor wells were installed and developed. In addition to installation of monitor wells, approximately 62 soil borings were also completed. The subsurface soil investigation portion of the Phase 2 RI is discussed in Subsection 2.3 of this report.

Appendix A3.4 of the Technical Plans (WESTON, August 1991) details the drilling and well installation protocols followed during Phase 2 sampling. Original plans called for all well drilling to be carried out using hollow-stem soil augers; however, difficult drilling conditions (e.g., boulders in the borehole) and the deeper drilling depths required at some locations forced WESTON to modify the original plan, first trying mud-rotary drilling with a roller bit and 6-inch casing and then using air-rotary drilling with an air hammer and 8-inch casing. Mud-rotary and air-rotary drilling techniques were used only at MW-19A, where Phase 1 geophysical results (seismic refraction) suggested that unconsolidated sediments are the thickest sediments at this location (up to 140 ft thick). All hollow-stem auger and mud-rotary drilling was completed by R & R International, Inc., of Akron, Ohio, while air-rotary drilling was completed by Hydro Group, Inc., of Dracut, Massachusetts.

Drilling and drilling supervision work were completed using modified Level D personal protective equipment (PPE). All soil removed during construction of monitor wells was stored on-site in sealed 55-gallon drums.

Field Adjustments

During drilling of MW-15A, large quantities of fine sand flowed up inside of and plugged the 10.5-inch soil augers. After several attempts to remove the plugged sand,



the driller determined that successfully installing a properly functioning monitor well at that location would be nearly impossible. Therefore, it was determined (with AEC approval) that the best solution was to abandon the hole and redrill another hole, while modifying the drilling technique slightly to reduce sand infiltration. The augers were removed and unplugged, the well was abandoned following well abandonment procedures outlined in the AEC drilling specifications, and a new hole was then drilled approximately 20 ft west of the previous location.

During drilling of MW-19A with mud rotary, refusal was encountered at 70 ft bgs. It was concluded that the refusal was probably not the result of bedrock, and the casing was removed and the well abandoned, following AEC-approved abandonment procedures. An alternate location for MW-19A was then selected approximately 20 ft west of the abandoned location, and another hole was drilled using air-rotary drilling.

During drilling of MW-20, geologic conditions were such that hollow-stem auger bits would bind up, making it difficult for the driller to rotate the augers in the hole. After drilling down 69 ft, the driller was inhibited from drilling deeper by severe binding, even though rock refusal had not been encountered. Basal till was encountered, but appears to be relatively thin based on other deep borings around the site, so bedrock was believed to be close to the augered depth.

Auger Drilling

R & R International used a CME-75 drill rig equipped with 10.5-inch, hollow-stem soil augers to complete all auger drilling required for installing monitor wells. Above the water table, continuous split-spoon soil samples were collected, while below the water table, split-spoon samples were collected at 5-ft intervals. Because of the cumbersome nature of the heavy 10.5-inch auger boring bits, continuous soil sampling above the water table was completed by the soil boring crew using 4.5-inch soil augers. Beneath the water table, soil sampling was completed by the well drilling crew.

All split-spoon samples were collected using 2-ft-by-1%-inch (inside diameter) split spoons. Standard penetration tests were completed using a 140-pound hammer with a 30-inch free-fall. All split-spoon soil samples were examined and described by a WESTON site geologist using the USCS. Lithographic samples were also collected.

Deep monitor wells were drilled to refusal, while shallow wells were drilled approximately 8 ft into the water table. A comparison of the projected bedrock depth (based on the Phase 1 geophysical survey) and the auger refusal depth suggested in most cases that refusal was bedrock. Adding water and drilling fluid (bentonite) to holes during drilling was avoided; however, in situations where the driller believed that successful completion of a well required the addition of mud or water, the site geologist allowed fluid to be added. Quantities of all fluids added during drilling were documented, and removal of lost drilling fluid was allowed for during well development.



Mud Rotary

Following one failed attempt to install MW-19A with soil augers, mud rotary was suggested to AEC officials as a possible alternate drilling technique. AEC agreed that an alternative method was desirable for installing MW-19A and that mud rotary was an appropriate method. As a result, an attempt was made to install MW-19A using mud rotary; however, this drilling technique encountered refusal at 70 ft. Because Phase 1 geophysics had suggested that bedrock at this location is significantly deeper than 70 ft, it was decided that the refusal was probably the result of a boulder and that a deeper hole should be attempted.

Air Rotary

To avoid the possibility of again encountering boring refusal, air-rotary drilling was selected, following a discussion with AEC, as an alternative to mud rotary for MW-19A. Air-rotary drilling was completed with a Barber drill rig, using a 6-inch air hammer with 8-inch steel casing. As required in the AEC drilling specifications, a 2-inch, in-line coalescing air filter was installed to reduce the potential of air compressor oil being blown down the borehole.

A Barber rig is a unique type of air-rotary drill rig that allows for simultaneous advancement of drill bit and steel casing through overburden. This technique is very useful for drilling through fine sand and other materials that could flow up inside of and clog the well casing. The air hammer drill bit is also able to drill through rock. Soil sampling was carried out by means of a 1%-inch-diameter split spoon attached to a wire-line sampler. Because of the difficulty in applying a consistent force to the split spoon, this technique does not allow for standard soil penetration tests (blow counts) to be completed when collecting split-spoon samples.

Weathered rock was encountered in MW-19A at 94 ft bgs. Drilling proceeded for another 15 ft through rock, at which point it was concluded to be bedrock. A bentonite slurry was used to grout the bedrock below MW-19A, and the well was then set at the till/bedrock interface.

2.4.2.3 Monitor Well Construction

After drilling to the desired well depth was completed (8 ft below the water table for shallow wells and boring refusal for deep wells), drilling stopped and tools were removed from the borehole. A 4-inch PVC monitor well was installed. A diagram showing a typical well construction is provided in Figure 2-1. The following procedure was used to construct each 4-inch well:

 Ten feet of 4-inch ID Schedule 40 PVC well screen was placed at the bottom of each well. The screen is of commercial manufacture with 0.010inch slotted openings.



- Four-inch threaded PVC Schedule 40 riser pipe was attached to the well screen and lowered into the borehole. Appropriate lengths of riser pipe were added so that the top of the PVC casing would be situated immediately below the flush-mounted road box planned at each location.
- Following placement of PVC pipe, silica sand was used to backfill each borehole to provide a filter pack around the well screen. The wells were backfilled with silica sand to 5 ft above the top of the well screen.
- A 5-ft bentonite plug (pellets or slurry) was added as a seal on top of the filter pack to minimize vertical infiltration of water into the screened area. Following injection of bentonite, the slurry was allowed to expand for several hours prior to injection of grout into the well.
- A cement/bentonite grout (20:1) was used to seal the remaining annular space to ground surface. The grout was tremied from the top of the bentonite seal to ground surface to ensure a proper seal.
- A 5-ft protective steel casing with a 6-inch locking pressure cap was installed, and a flush-mounted cap was installed. A 36-inch-by-36-inch concrete pad was constructed around each well.

2.4.2.4 Well Development

Well development began a minimum of 48 hours after completion of construction of each well. Well development was conducted using a 3-inch, 1/2-horsepower, stainless steel Grundfos submersible pump with an approximately 10-gallons-per-minute (gpm) maximum pumping rate. Low-yielding wells were also bailed with a 3-inch PVC bailer. Surging of wells was completed by rapidly raising and lowering the submersible pump or bailer inside the well casing. Original plans called for removing a minimum of five times the standing water volume in each well (using the submersible pump), plus five times the water calculated to be in the well sand pack, plus five times the volume of fluid lost during monitor well installation; however, several wells were pumped dry long before the minimum well volume had been pumped, and these were slow to recover to their original static levels. The AEC geologist suggested, as an alternative technique, pumping the wells dry and allowing them to recover for a minimum of 4 hours, then evacuating them again using the alternative technique. Well evacuation was completed a minimum of five times, or until specific conductivity and pH values between consecutive evacuations were within 10% of each other. During well development, specific conductivity, pH, and temperature were measured at the start, middle, and end of the pumping period. Table 2-1 summarizes this well development data, and well development forms are provided for each well in Appendix D.

All development water was field-screened for volatiles and gamma radiation, and if neither was detected, water was discharged onto the ground. If volatiles or radiation above background were detected, water was stored on-site in sealed 55-gallon drums.



Development water from one well, MW-18, needed to be containerized because of elevated volatiles in groundwater.

2.4.3 SLUG TESTING

To evaluate hydraulic conductivity of geologic material, slug tests were completed in selected monitor wells between 17 December and 20 December 1991. The slug test was developed by Ferris and Knowles (1954) as a method of estimating aquifer conductivity. The test consists of instantaneously introducing a known volume into a monitor well, causing a change in water level. The rate at which the water level in the well returns to its original level is a function of the aquifer's ability to transmit water. Hydraulic conductivity and transmissivity values obtained from the slug test analysis are representative only of material within close proximity of the well; however, by performing the tests at several locations, one may obtain an assessment of aquifer conductivity.

The testing was completed using a 5-ft-by-2.5-inch solid-mass PVC slug. The slug was introduced into the well, and water-level response was recorded with an In-Situ Corporation SE-2000 data logger attached to a pressure transducer. Following introduction of the slug, the aquifer was allowed to recover for a minimum of 2 hours, or until the water level in the well recovered to 90% of its original water level. The slug was then pulled, and aquifer response rate was measured. Following removal of the slug, the aquifer was again allowed to recover for a minimum of 2 hours or until water levels in wells reached 90% recovery. To reduce the possibility of cross-contamination, all slug test equipment was decontaminated between wells. Slug testing was completed on shallow monitor wells MW-15, MW-16, MW-17, and MW-19 and on deep monitor wells MW-15A, MW-16A, MW-17A, and MW-19A. Through testing of well clusters, assessments of both vertical and horizontal variations in hydraulic conductivity were made.

2.4.4 GROUNDWATER LEVEL MEASUREMENTS

As part of the groundwater investigation, water levels were collected in all 15 new and 16 previously installed wells at the site. Complete rounds of water-level measurements were obtained monthly between Phase 1 well installation and April 1992. Contoured water-level data were used to assess hydraulic gradients, groundwater flow direction, and velocity. In addition, well couplets were used to assess vertical gradients and vertical flow components.

2.4.5 GROUNDWATER SAMPLING

Between 9 December and 16 December 1991, groundwater sampling of 31 wells was completed. Water samples from all wells were analyzed for the following parameters:

- TCL VOCs
- TCL semivolatile organic compounds (SVOCs)
- TAL metals



- Cyanide
- Pesticides/PCBs
- Radiologic parameters
 - Gross alpha
 - Gross beta
 - U-234
 - U-235
 - U-238

In addition, nitrate analysis was also completed on samples collected from MW-6, MW-8, C-3, and MW-20. Finally, samples collected from MW-6, MW-8, and MW-20 were analyzed for explosives.

All sampling was performed based on AEC technical specifications. Any deviations from AEC specifications were approved by AEC prior to the start of the Phase 2 RI.

The procedures used for the groundwater monitoring were as follows:

- All groundwater sampling was completed a minimum of 2 weeks after installation of monitor wells. This minimum time interval was selected so that groundwater could recover to equilibrium following well installation.
- To determine the volume of water in each well, the water level was measured with an electric water-level tape. All measuring devices used in wells were decontaminated with deionized water between wells.
- To ensure that groundwater samples collected were representative of the aquifer, a quantity of water equal to a minimum of five times the calculated volume of water in the well casing and sand pack was removed prior to sample collection.
- If, during purging, a well went dry and took longer than 4 hours to recover, it was purged dry a minimum of two times, rather than removing five well volumes. This approach was recommended by the AEC geologist.
- Stable temperature, pH, and specific conductivity measurements were used to evaluate the effectiveness of well purging. If, after purging the required minimum well volume, parameters failed to stabilize, purging continued until measurements taken during consecutive evacuations were within 10% of each other. All measurements were recorded on groundwater sampling forms, which are presented in Appendix G.
- Following purging of monitor wells, water samples were collected for chemical analysis within 24 hours of the completion of well purging.



- A Teflon, bottom-filling bailer was used to obtain groundwater samples from each well.
- Bailers and purging pumps were decontaminated following sampling of each well using an AEC-approved water source to prevent crosscontamination between sampling wells.

Additional field QA/QC samples were collected as follows:

- Field/equipment blank: collected one per day for all analytes sampled on that day.
- Trip blank: submitted one per day per cooler for VOCs only.
- Duplicates: collected one complete set of duplicate samples per 20 or fewer samples.

All purge water was field-screened for VOCs and gamma radiation, and groundwater showing concentrations above background was placed in 55-gallon sealed drums. Purge water from wells C-2, MW-18, and MW-23 was placed in drums as a result of elevated VOC concentrations. Monitor well sampling is summarized in Table 2-2. The containers and preservatives used for all water samples collected during the Phase 2 RI are presented in Table 2-3.

2.4.6 SURVEY OF MONITOR WELLS

A topographic survey of all new wells at MTL was conducted by a Massachusetts licensed land surveyor, Harry R. Feldman, Inc., of Boston, Massachusetts. To determine horizontal coordinates for each new well, a traverse survey was completed using an electronic distance measurer (EDM). Ground surface and top of PVC casing elevations were measured for each new well to 0.1-ft accuracy. Survey notes are presented in Appendix C.

2.5 SURFACE SOIL INVESTIGATION

2.5.1 OBJECTIVE

The Phase 2 surface soil sampling program at MTL had three objectives:

- To characterize the effects of past and present facility activities on the surrounding site soils.
- To evaluate the lateral extent of surface soil contamination at MTL.
- To obtain sufficient data for use in an RA whose objective is to estimate potential health risks (if any) posed by existing surface contamination and the need for remediation at MTL.



2.5.2 SURFACE SOIL SAMPLING

To characterize the effects of past and present facility operations on the surrounding surface soils, a total of 30 surface soil samples were collected on facility grounds. Table 2-4 provides a summary of the surface soil samples collected as part of the Phase 2 field effort. Appendix G provides field sampling forms for the surface soil sampling effort. Appendix M contains photographs of a number of the surface soil sample locations. Results of the Phase 2 surface soil sampling at MTL are presented in Subsection 4.3.

Phase 2 surface soil samples were collected as either discrete or composite samples as provided for in the TSP. In either case, soil was collected (generally from a depth of 0 to 6 inches) with a stainless steel trowel and homogenized in a stainless steel bowl. Aliquots were apportioned to each sample jar. Sample containers, preservation, and holding times are detailed in Table 2-5.

2.6 CHARLES RIVER WATER AND SEDIMENT INVESTIGATION

2.6.1 OBJECTIVE

The objectives of the Charles River surface water and sediment investigation were to determine the potential impact of past and present MTL activities on the Charles River from storm sewer outfalls discharging to the river and to assess the risk to human and ecological receptors from direct contact and/or ingestion of contaminated surface water and/or sediment.

2.6.2 SURFACE WATER SAMPLING

Surface water samples were collected at 14 stations in the Charles River during this investigation from 28 to 29 October and from 5 to 6 November 1991. Additional sampling was conducted in April 1992 for pesticides/PCBs and hexavalent chromium and September 1993 to obtain lower detection limits for several metals. Additional water samples collected from the storm sewers discharging to the river are described in Subsection 2.7. Surface water sample locations were selected to describe conditions upstream of, adjacent to, and downstream of the MTL site and the storm sewer outfalls. Table 2-6 summarizes the surface water (and sediment) sampling investigation at MTL.

Samples were collected from a boat, starting with the furthest downstream location and moving upstream to eliminate the potential for cross-contamination from transport of disturbed sediments. In addition, water samples were collected prior to sediment sampling at each location. Water temperature, pH, specific conductance, depth, and other site-specific descriptions were recorded at each location. The location of each surface water (and sediment) sample location was logged in the field notebook and marked/verified on a project map.



The following list outlines the procedures used for surface water sampling from the Charles River at MTL. Surface water samples were collected as follows:

- Sample station was located and marked with wooden stake and labeled with the appropriate sample identification number. Stakes were placed along the shoreline of the Charles River as close as possible to the sample locations.
- Stations located in water depths ≤4 ft were sampled by immersing each labeled sample bottle just below the water surface until filled.
- Stations located in water depths >4 ft were sampled at mid-depth using a decontaminated stainless steel Kemmerer water sampler.
- Samples were placed in a cooler maintained at 4 °C after collection.
- All required information on sample collection and other pertinent data were recorded in the field notebook at each station.

2.6.3 SEDIMENT SAMPLING

Sediment samples were collected at 18 locations in the Charles River and from five storm sewer outfalls in and above the Charles River during the investigation. Sediment samples were collected at the same locations sampled for surface water, with additional sediment samples collected at or near storm sewer outfalls. Sediment samples, including SD-4P, SD-5P, SD-6P, SD-9P, and SD-14P, were collected at or near the outfalls of five storm sewer pipes. The outfall for sample SD-7P could not be located and may no longer exist as a defined pipe, so this pipe sediment sample could not be collected; however, a riverbed sample was collected at this location. No sediment fines were present at Station 16, so only a surface water sample was collected there. Table 2-6 summarizes the sediment (and surface water) investigation at MTL.

Sediment samples were collected to determine potential impacts/contamination resulting from MTL storm sewer outfalls. Samples were collected at or downstream of submerged storm sewer outfalls and directly from exposed outfalls at or above the water level of the Charles River. Additional samples were collected at two depths from six locations to determine historic sediment contamination (shallow and deep). The location of each sediment sample was logged in the field notebook and marked on the project map. Notes describing the presence of sheens and odors, sediment color, substrate composition, and other pertinent information were also recorded at each location.



The following is an outline of the procedures used for sampling sediments from the Charles River and MTL storm sewer outfalls:

- Sample station location was marked with the appropriate sample identification number. Wooden stakes were placed along the shoreline of the Charles River as close as possible to the sample locations.
- Sediment samples were collected at each Charles River location after collecting the surface water sample. The 0- to 6-inch sediment samples were collected using a decontaminated stainless steel petite ponar dredge sampler. Several ponar grab samples were collected at each location and composited in a decontaminated stainless steel mixing bowl. VOC samples were placed immediately in the appropriate bottles prior to mixing the composite samples. The remainder of the sample bottles were subsequently filled using a decontaminated stainless steel scoop after thoroughly mixing the grab samples.
- For deeper samples (12 to 18 inches), sediments were collected using a decontaminated 2-inch-diameter stainless steel bucket auger. Samples were composited and processed as described above for shallow (0 to 6 inches) sediment samples.
- Decontaminated stainless steel scoops were used to collect sediment samples from exposed storm sewer outfalls and those outfalls located above the water level of the Charles River. Samples were composited and processed as described above.
- Samples were placed on ice in clean coolers after collection.
- All required information was recorded in the field notebook at each station.

2.7 STORM SEWER INVESTIGATION

2.7.1 OBJECTIVES

The objectives of the storm sewer portion of the field investigation are as follows:

- To measure the amount of stormwater flow generated by a typical precipitation event at each of the major exit points in the storm sewer system.
- To determine and quantify what chemical and radiological contamination, if any, may be present in the surface runoff discharging from the MTL site.



2.7.2 INSPECTION

Activities associated with inspection of the stormwater sewer and installation of flow monitoring and sampling equipment were conducted from 2 December through 14 December 1991.

Preliminary activities consisted of verifying monitoring/sampling locations throughout and around the perimeter of the MTL stormwater sewer system. It was anticipated that monitoring/sampling locations would be established at the stormwater outfalls located on the north bank of the Charles River. This initial strategy was reevaluated during the preliminary activities. Because of the lack of security at these locations (i.e., the risk of vandalism to unprotected equipment) and also because the outfall pipes were partially submerged in the Charles River (which would have made accurate monitoring and sampling of stormwater flows impossible), alternative monitoring/sampling locations were necessary.

A reconnaissance survey of the stormwater sewer was subsequently conducted to determine alternative monitoring/sampling locations, to confirm the configuration of the system, and to identify any discrepancies between the existing stormwater sewer system and available maps of the system. Seven monitoring/sampling locations (two background locations and five "outfalls") were identified. Descriptions of the monitoring/sampling locations are as follows:

- Background 1 Manhole located south of Arsenal Street between Building 311 and site fence (SW-1). Meter and sampler set up in incoming pipe.
- Background 2 Manhole located on North Beacon Street between Bay Street and Charles River Road (SW-21). Meter and sampler set up in incoming (west side) pipe.
- Outfall 1 Manhole located at intersection of Charles River Road and North Beacon Street (SW-4P). Meter and sampler set up in incoming pipe.
- Outfall 2 Manhole located south of North Beacon Street inside Watertown Yacht Club fence line (SW-5P). Meter and sampler set up in incoming line.
- Outfall 3 Manhole located west of Building 652 (SW-7P). Manhole appeared to be recently constructed and is not shown on any of the stormwater sewer system drawings. Meter and sampler set up in outgoing pipe. Recording rain gauge also set up at this location (on roof of Building 652).
- Outfall 5/6 Manhole located southwest of Building 117 (SW-10P).
 Designated 5/6 because original drawing showed two outfall pipes exiting



in this area. Field check confirmed that only one exit pipe existed. Meter and sampler installed in incoming pipe.

Outfall 7 — Manhole located at south end of Talcott Street, east of guard shack (SW-14P). Meter and sampler installed in outgoing pipe. Upon inspection, it was discovered that this pipe was partially blocked by sediment and debris. This would result in erroneously high flow measurements from the flow meters; however, this was the only viable location at which to install the instrumentation to gather information about this portion of the site.

2.7.3 SAMPLING AND FLOW MONITORING PROCEDURE

Sampling and flow monitoring were conducted on 12 December 1991. The automatic composite samplers were programmed to begin sampling when an increase in flow was detected by the flow meters. A grab sample was collected by the sampler during the initial period of runoff ("first flush"). This sample was analyzed for VOCs. The remaining sample was collected as a flow composite. Three individual aliquots were collected at predetermined flow intervals ranging from 50 gallons to 1,000 gallons. This flow composite sample was submitted for the remaining chemical parameters.

Several factors were considered in the selection of a flow monitoring method for MTL. The flow rate in the stormwater sewer would be directly dependent on the magnitude of the precipitation event that caused this flow to occur. Since it would be impossible to forecast the magnitude of any given precipitation event, it would also be impossible to predict how much flow could be expected in the stormwater sewer. This would make it extremely difficult to properly size a primary measuring device that would accurately measure flow.

Because of these factors, it was felt that the use of primary measuring devices (i.e., weirs or flumes) would be inappropriate for the flow monitoring program at MTL. Therefore, it was decided to employ a method based on Manning's formula. If the cross-section of the conduit is uniform, the slope and roughness of the conduit are known, and the flow is moved by the force of gravity only, the rate of flow in the conduit may be calculated using Manning's formula:

$$Q = \frac{1.49}{n} AR^{\frac{2}{3}} S^{\frac{1}{2}}$$

where

 $Q = Quantity of flow in ft^3 per second.$

n = Manning roughness coefficient dependent upon material of conduit.

A = Cross-sectional area of flow in ft².

R = Hydraulic radius in ft.

S = Slope of the hydraulic gradient.



Manning's formula is commonly used to calculate the rate of flow in circular conduits or round sewer pipes.

Ideally, the use of Manning's formula requires the following:

- A straight course of channel for at least 200 ft upstream of the point where depth measurement is required.
- The conduit channel should be nearly uniform in slope, cross-section, and roughness and should be free of rapids, abrupt dips, sudden contractions or expansions, and tributary inflows.
- The slope of a given conduit must be known or accurately estimable.
- There should be no downstream backup or submerged flow.

Despite these prerequisites, it was felt that more accurate flow measurements could be attained using the Manning formula.

To measure the depth of flow and subsequently calculate the flow rate, a continuously recording flow meter (Isco® Model 3230 Flow Meter) was installed at each of the monitoring locations. The level measuring device is a bubbler that measures the liquid in the flow stream. The bubbler system works in the following manner. A small air compressor pumps air into a reservoir. This air is released slowly by a needle valve into a bubble line, which is a small flexible tube. The end of this tube is submerged in the flow stream. Through a tee fitting inside the flow meter cabinet, the bubble line is connected to one side of a differential pressure transducer. As air is released slowly into the bubble line by the needle valve, air pressure builds inside the line, forcing the air out of the line into the flow stream. When enough air is released, a bubble will be forced from the end of the line into the stream. The amount of air pressure required to force the bubble from the end of the line is directly dependent on the hydrostatic pressure of the flow stream above the end of the bubble line. The pressure transducer inside the flow meter (connected to the bubble line through the tee fitting) senses this pressure and converts it into an electrical signal, which the Model 3230 converts into level. Parameters for calculating flow (i.e., slope, roughness coefficient, pipe diameter) are entered into the meter. Flow rate and quantity are then calculated from the level of flow by the meter's central processing unit (CPU). Measured and calculated results are stored in the meter's memory and printed at designated intervals.

2.8 RADIOLOGICAL INVESTIGATION

2.8.1 OBJECTIVE

The objective of the radiological survey program is to characterize the extent of radiological contamination at the site. The radionuclide of primary concern is DU, which is uranium depleted into U-238. Operations involving DU included machining,



grinding, electroplating, cutting, melting and forging, chemical analysis, and incineration of DU.

Other radionuclides that may be present in much smaller amounts include cobalt-60 (Co-60), Cs-137, radium, and thorium. If present, Co-60 and Cs-137 would have been generated by operations of the research reactor located on-site. The research reactor was not part of the scope of this investigation. Except for small amounts of thorium stock, all other radioactive isotopes are sealed sources. Contamination from radioactive material that emits alpha, beta, and gamma radiation resulted from previous research and machining operations. The buildings on the site have been classified for the purposes of this investigation as contaminated, suspected, and not suspected. These classifications are based on past site investigations and previous uses of radioactive materials on the site.

Prior to surveying contaminated areas at MTL, an instrument survey was completed to determine natural background radiation levels for both indoor and outdoor areas located on and around the site.

Analytical results of the radiological survey are presented in detail in the Radiological Field Survey Report (WESTON, February 1992). The objectives of the radiological survey included the following:

- Identify indoor and outdoor areas where radionuclide concentrations are higher than natural background levels.
- Identify the radionuclides present in these areas.
- Obtain the preliminary information necessary to develop a facility decontamination and decommissioning plan.
- Provide adequate sampling results to support eventual release, for unrestricted use, of buildings that are not suspected of contamination.

Description field activities specific to the research reactor and its decommissioning are being conducted under a separate program by another contractor.

2.8.2 OUTDOOR RADIOLOGICAL SURVEY

The outdoor radiological survey was performed to evaluate the possible presence of radionuclides in surface soils on the site. The survey was based on instrument readings only. Soil, groundwater, and surface water sampling will be discussed elsewhere. The survey was performed using the NaI gamma detector because uneven surfaces and vegetation make it difficult to detect alpha and beta particles outdoors. Therefore, the outdoor areas were investigated by surveying with gamma monitoring devices and collecting and analyzing surface and subsurface soil samples for radionuclides.



A radiological background survey was performed to establish off-site natural background radiation levels. A total of 11 background readings were taken at four different off-site locations. The average of these background readings were compared with on-site radiation readings during the outdoor survey.

The survey of the grounds consisted of a walkover with an NaI gamma detector. The NaI detector has a special geometry that makes it most sensitive to low-energy gamma radiation, which is emitted by DU. The grounds were divided into suspected and nonsuspected areas for a more thorough characterization. The suspected grounds included the approximately 30-ft perimeter surrounding each of the nine contaminated or suspected buildings. The perimeter was divided into approximately 5-ft lanes, and an NaI gamma detector was used to survey each lane. Readings were recorded every 5 ft. Readings were collected at an average distance of 3 inches above ground surface.

The rest of the grounds were classified as not suspected. This area was divided into approximately 20-ft lanes, and an NaI gamma detector reading was taken in the middle of each lane. Readings were recorded every 5 ft. In addition, the area located south of North Beacon Street toward the Charles River and the southern portion of the site along North Beacon Street were also surveyed at intervals of 20 ft.

The outdoor radiological investigation will identify contamination in the surface soil from dust or surface spills of DU, possible releases from the reactor to the environment, and laboratory radionuclides that may have been released to the surrounding soils and groundwater.

2.8.3 INDOOR SURVEY

The buildings on the site were investigated using portable radiation detectors and swipe sampling. The pancake Geiger-Mueller (G-M) detector, a ZnS scintillation detector, and an NaI gamma detector were used to evaluate the alpha, beta, and gamma activity levels within each building. Instrument efficiencies were determined for the ZnS and pancake G-M detectors using a natural uranium disk. The instrument efficiency was recorded on a daily efficiency log at the start of each workday. The NaI gamma detector was calibrated by correlating readings at several locations with those of a pressurized ionization chamber (PIC).

All WESTON radiation detectors are calibrated annually or after repair. The instruments are sent to the manufacturer to be calibrated, and the manufacturer calibrates the instruments using National Institute of Standards and Technology (NIST) traceable or referenced standards in accordance with the requirements of American National Standards Institute (ANSI) Standard N323-1978. Specifically, the PIC is calibrated with NIST traceable or referenced standards by Reuter-Stokes. A table of instruments and calibration dates is included in Appendix S.6.

A ZnS alpha swipe counter and a plastic scintillator beta swipe counter located in the operations laboratory were used to analyze the swipe samples. These swipe samples were analyzed to determine the amount of removable gross alpha and gross beta



contamination. Table 2-7 provides a list of the radiation survey instruments, their lower detection limits, and the type of radiation detected by each instrument. Off-site indoor background readings were also taken in buildings that are similar in structure and construction to the buildings at MTL. Table 2-8 identifies the date and type of construction for each off-site indoor background reading location.

The extent of the survey varied depending on the classification of each building and the degree of contamination found. Fewer radiological readings were taken in contaminated buildings and buildings suspected of contamination than in buildings not suspected of contamination. This is because remediation is expected to be required in the contaminated areas, and a final survey would be required following remediation.

2.8.3.1 Contaminated Buildings

Previous radiation surveys have determined that Building 43, the DU foundry, and Building 312, the DU machining area, are contaminated with radionuclides.

All rooms within these two buildings were scanned with an NaI gamma detector, a pancake G-M detector, and a ZnS alpha detector. The survey was concentrated on points of likely contamination, such as drain openings, fume hoods, pipe chase holes, areas where floor tiles are broken or missing, cracks in floors, floor trench drains and drain traps, in-ground collection sumps, and other accumulation points.

Where possible, trench drains, drain traps, and in-ground sumps were opened, and readings were taken inside. If elevated readings were noted, then a swipe sample was taken. The radiation readings and location of each building were recorded for the three instruments. The number of readings varied based on the level of contamination in each room and the size of the room. Generally, more readings were taken in large areas, such as the high-bay area of Building 43.

2.8.3.2 <u>Buildings Suspected of Contamination</u>

The seven buildings (37, 39, 97, 241, 292, 311, 313) classified under this category were found to have contained radionuclides or to have been used for work involving radioactive materials in the past.

All rooms within these buildings were scanned with an NaI gamma detector and a pancake G-M detector. Special attention was given to points of likely contamination, such as drain openings, cracks in the floors, corners of rooms, and other areas where dust and dirt normally accumulate. A limited survey was conducted of drain traps, ventilation exhaust vents, and accessible areas above drop ceilings. All areas with elevated readings were surveyed with a ZnS alpha detector, and a 100-cm² wipe sample was taken. Readings for the three instruments were recorded at seven locations per room, with more readings recorded for larger rooms.



2.8.3.3 Buildings Not Suspected of Contamination

These buildings were reported as having no detectable concentrations of radiological parameters exceeding natural background levels during previous studies, and based on past uses, there is no record that they ever contained radionuclides.

A detailed survey meeting the NRC's "Final Survey" criteria for release of a building for unrestricted use was performed in the not suspected buildings. All rooms and surfaces within each not suspected building were scanned with the pancake G-M, ZnS alpha, and NaI gamma detectors to locate any areas of elevated radiation levels and identify any radioactive stock materials present in the buildings.

A 2-meter grid system was established in each room and all common areas throughout each building. The grid system covered all floor areas and the lower portions of all interior walls up to 2 meters above floor level. A random-number generator was used to select approximately 10% of the grids. Five readings each were taken with the ZnS alpha detector, the pancake G-M detector, and the NaI gamma detector.

One 100-cm² swipe sample was taken within each grid at the point where the highest radiation reading was observed. The swipe sample was analyzed for removable alpha and beta contamination. This detailed survey will verify that no radiological contamination exists in these buildings.

2.8.4 REMOVABILITY STUDY

Low-level radioactive contamination has been identified on a variety of surfaces including the following:

- Concrete floors
- Floor tiles
- Painted concrete and plaster walls
- Metal drains
- Laboratory benches

To release the facility from its NRC license, the radioactive contamination must be removed sufficiently to meet NRC guidelines for unrestricted use of the structure. In addition, DPH guidelines must also be followed.

A removability study was performed to determine what decontamination techniques would be necessary to successfully reduce radioactive contamination to appropriate cleanup levels. Increasingly aggressive decontamination techniques were attempted on various contaminated surfaces at MTL, including the following:

- Vacuuming
- Washing with scrub brush, water, and detergent (alconox)
- Washing with wire brush, water, and detergent
- Removing floor covering material and wire brushing underlying floor



Scraping and chipping floor with a hammer and chisel

These were used until a technique that successfully reduced the contamination level to natural background levels was found.

2.8.5 MISCELLANEOUS SURVEYS

2.8.5.1 Borehole Radiation Investigation

Several boreholes were drilled in buildings that were previously used or suspected of being used for housing DU operations and in outdoor areas throughout the installation. Subsurface soil samples were collected and analyzed for gross alpha, gross beta, U-234, U-235, and U-238. Prior to the installation of the borehole casing or the filling in of the borehole, a gamma detector was lowered down into the boreholes. Radiation readings obtained were compared to off-site borehole radiation readings.

2.8.5.2 Building Roof/Rafters Survey

An informal survey was performed of the roof and rafters in Buildings 39, 43, and 311. In each building, areas around ventilation exhaust vents, dust accumulation points on the rafters, and random locations were surveyed with a pancake G-M detector. A systematic survey was not conducted, because if contamination were to exist on the roof, it would most likely be at a maximum around exhaust vents.

2.8.5.3 Steam Tunnels Survey

A general survey of the steam tunnels that interconnect some of the buildings was completed using a pancake G-M detector. The survey was concentrated in areas where spillage of materials would accumulate (e.g., cracks, holes, sumps). A review of the facility drawings and a visual inspection were performed to verify that no sanitary sewer lines or drainlines from contaminated buildings flow through or discharge into the steam tunnels.

2.8.5.4 <u>Drainlines Investigation</u>

Drains in Buildings 39, 43, 292, and 312 were found to have elevated radiation levels; it is possible that the piping systems into which these drains empty are also contaminated. Since it was not possible to determine where the drains discharge based on a review of the facility drawings, dye tests were performed for all drains with elevated radiation readings.

Several manholes were opened to provide access to the sanitary system. The sanitary sewer lines flow through a trench in the bottom of the manholes. Sediment traps were found in a manhole on Arsenal Street downstream of Building 43 and in a manhole on Beacon Street downstream of Building 39. A pancake G-M detector was used to survey the accumulated sediments. Sediment samples were also taken and analyzed for radionuclides.



2.8.5.5 Hoods and Ventilation Systems

A limited survey of the ductwork above hoods and other ventilation lines was completed. For hoods that were located over contaminated surfaces or were in rooms with contamination, the exhaust duct above the hood was surveyed as far as could be reached with a pancake G-M detector. No elevated readings above background were found. This limited survey was performed in Buildings 39 and 97.

There are separate vacuum ventilation systems for the beryllium and DU machine shops in Building 312. Each system discharges to two cyclone separators, a filter, and a blower on the third floor that exhausts to a pipe that goes through the roof. These systems were not surveyed but were assumed to be contaminated.

The ventilation systems in Building 43, one for the DU incinerator and one for the DU melter, were not surveyed but were assumed to be contaminated.

2.9 INDOOR SURFACE CHEMICAL SAMPLING INVESTIGATION

2.9.1 OBJECTIVES

The objectives of the indoor surface chemical sampling investigation (chemical wipe sampling) were as follows:

- To determine whether activities in facility buildings have resulted in significant surficial contamination to permanent indoor surfaces such as walls, floors, ventilation systems, and floor drains.
- To estimate potential health risks posed by surficial contamination to present and future inhabitants of the site to determine the need for remediation.

2.9.2 INDOOR SURFACE CHEMICAL SAMPLING

As part of the Phase 2 RI, a comprehensive indoor wipe sampling program was conducted throughout the installation. A total of 855 indoor surface locations were sampled. Table 2-9 summarizes the buildings sampled, the number of rooms sampled in each building, and the total number of wipe sample locations per building. Floor plans of each building showing the rooms in which wipe samples were collected are provided in Appendix I.

Wipe samples were collected as either discrete or composite samples using gauze pads wetted with the solvent appropriate for removal of the analyte desired. For each pad, a 100-cm² area was wiped. Discrete samples consisted of one pad only. Composite samples of walls and floors totaling up to 400 cm² in the wiped area were collected using multiple gauze pads at multiple locations within the room. The specific analyses requested depended on the history of the room wiped as well as the history of the building itself. Because there are 855 samples to account for, a sample-by-sample



description of analyses is not provided. Table 4-56 is intended to meet this purpose. Table 2-10 outlines the solvent preservation and holding time for the chemical wipe sample analyses requested as part of the Phase 2 effort. For every 20 samples or less, a duplicate sample was collected. For duplicate samples, the area immediately adjacent to the sample location being duplicated was wiped. In addition, a wipe blank sample was collected each day. Blank samples were collected by wetting the pads with the appropriate solvent and placing them in the sample bottles without wiping any surface.

To account for the phthalates associated with the latex surgical gloves used during wipe sampling, several "glove blanks" were collected by wiping the latex gloves with the appropriately wetted gauze pads.

Specific wipe sampling locations were chosen in the field by sampling field crews, based on the following criteria:

- Available information for the rooms sampled, such as room size and past and present uses. Office areas were not sampled.
- Existence of appurtenances requiring sampling, such as floor drains, fume hoods, and local exhaust vents.
- Field observations, such as staining, proximity to potential spills, or splashing.
- Information obtained from facility personnel at the time of sampling.
- Field monitoring instrument readings.

For comparative purposes, off-site background wipe samples were also collected in other buildings in Watertown, as listed below:

- Watertown Firehouse
- R. H. Green Co. (lumber/hardware vendor)
- Hellenic Council Center
- Cuniff Elementary School

2.10 INDOOR AIR INVESTIGATION

2.10.1 AIR SAMPLING OBJECTIVE

Air sampling was conducted in buildings and structures whose history indicated the possibility of air contamination and whose structure indicated the possibility of future human access. Background samples were collected from outdoor areas of the site that are removed from contaminant sources to provide information on the origin of possible contaminants in indoor air. In addition, Massachusetts Department of Environmental Protection (MADEP) outdoor air samples from two locations in the Boston area were used for comparison with MTL indoor air samples. These MADEP samples are



discussed further in Subsection 4.10.1. Table 2-11 provides a summary of air sampling locations and analyses performed.

2.10.2 AIR SAMPLING METHODOLOGY

Air sampling was conducted using various reference, EPA, and National Institute for Occupational Safety and Health (NIOSH) methods and modifications to these methods to analyze for a large variety of compounds that may have been present in the ambient indoor air. The same methods were used for indoor and outdoor ambient air sampling because of the low detection limits that can be achieved. All samples were collected over a 24-hour period at each location. This determined outdoor ambient background air concentrations. In each building to be sampled, samples were located in a representative location that was not affected by unusual activities (i.e., indoor borings). Samples were collected at a height of 1 to 2 meters, which is representative of the breathing zone.

Samplers (equipment) were rotated among sampling locations. Samplers were placed in accessible locations and where the potential for contamination was greatest. These locations were determined during a presampling walk-through by the air sampling team.

Sampling was conducted using various methods, with each incorporating its own sampling/analytical methodologies, QA, and calibration procedures. Copies of sample calibrations are presented in Appendix I.3.

2.10.2.1 VOC Air Sampling

VOC air sampling was conducted using EPA Method TO-14, Determination of VOCs in Ambient Air Using SUMMA® Passivated Canister Sampling and Gas Chromatography (GC) Analysis. This method involves collection of a whole air sample that is integrated over a 24-hour period and collected in a SUMMA® passivated canister. The canister is initially cleaned and evacuated when received from the laboratory and filled using an automated mass flow-controlled system to provide an integrated sample.

Samples were analyzed for the TCL VOCs plus the following eight volatile compounds:

- 1,3-butadiene
- 2-chloroethyl vinyl ether
- 1,2-dibromoethane
- 1,2-dichlorobenzene
- 1.3-dichlorobenzene
- 1,4-dichlorobenzene
- Trichlorofluoromethane
- Trichlorotrifluoroethane



2.10.2.2 Semivolatiles (PAHs and PCBs) Air Sampling

Polynuclear aromatic hydrocarbon (PAH) air sampling was conducted using EPA Method TO-13, Determination of Benzo(a)pyrene and other PAHs in Ambient Air Using GC and High-Performance Liquid Chromatography (HPLC). TO-13 uses a high-volume polyurethane foam (PUF) sampler that draws approximately 225 liters per minute (L/min) of sample through a glass-fiber filter and sandwich of PUF and XAD-2 resin. Each sampling unit is calibrated with reference orifices to obtain a flow curve that will be used in the determination of the final flow rate. The PAHs analyzed include the following:

- Acenaphthylene
- Acenaphthene
- Anthracene
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Benzo(ghi)perylene
- Chrysene

- Dibenzo(a,h)anthracene
- Fluoranthene
- Fluorene
- Indeno(1,2,3-cd)pyrene
- Naphthalene
- Phenanthrene
- Pyrene
- Methylnaphthalenes

EPA Method TO-4, Method for the Determination of Organochlorine Pesticides and PCBs in Ambient Air, was used to conduct PCB sampling. Sampler operations and sample media are the same as those used for TO-13.

2.10.2.3 Explosive Compounds and Nitrates Air Sampling

Air sampling for explosive compounds was conducted using a modification of WESTON's Analytics Division Method SP No. 21-15-0550.1, Sampling/Analytical Method for 2,4,6-trinitrotoluene. The samples were collected using the high-volume PUF method described in the previous subsection. The sample was drawn through a 102-mm-diameter glass quartz filter and then through a cartridge containing 70 grams of XAD-2 resin. The XAD-2 resin and the filter were extracted using a modified procedure of the method. The estimated sample rate was approximately 140 L/min. To determine whether breakthrough had occurred, one sample was taken in an area where the presence of nitrates was expected with a 20-gram XAD-2 backup to the primary 50-gram front half. The back half was analyzed separately to determine if breakthrough had occurred.

Particulate nitrates were collected using an annular denuder system (ADS). The ADS technology is the basis of EPA Compendium Chapter IP-9, Determination of Reactive Acidic and Basic Gases and Particulate Matter in Indoor Air. Because of the reactive nature of gases on the particulate nitrates collected on the filter, these gases had to be removed from the sample to avoid underestimation of nitrate concentrations. At a sample flow rate of 10 L/min, the sample was passed over concentric glass tubes coated with sodium carbonate, with the particulates collected in a cyclone bypass and on a



filter pack at the end of the sample train. The sodium carbonate would absorb the reactive gases before they reached the nitrate particulates on the filter.

2.10.2.4 <u>Total Suspended Particulate (TSP) for the Determination of U-234, U-235, U-238</u>

Samples for U-234, U-235, and U-238 were collected using a high-volume TSP sampler. The sampler was operated as specified in Appendix B of 40 CFR 50. The sampler was calibrated to a 40-cubic-feet-per-minute (cfm) flow rate using a reference orifice, which was maintained by a mass flow controller. The 8-by-10-inch glass quartz filter collected TSP, which was analyzed for the specified uranium isotopes. Since glass quartz filters may contain some uranium, a blank sample was also analyzed.

2.10.2.5 Particulate Matter Less Than or Equal to 10 Microns (PM-10) in Ambient Air for TAL Metals

PM-10 samples were collected in accordance with Appendix J of 40 CFR 50. The sampler operates in the same manner as the TSP sampler. A special inlet head separates particulates so that only particulates of 10 microns or less are collected on the 8-by-10-inch glass quartz filter. The filter was pre- and postweighed to determine total particulate content, and the filter was digested for TAL metals analysis.

2.10.2.6 Cyanide Aerosols and Gases in Air

Cyanide aerosols and gases were measured by a modified NIOSH Method 7904. Modification of the method involved an increase in the filter size, additional bubbles solution, and increased flow rate. The flow rate was increased to 2 L/min and the total bubble solution was 180 ml. The total impinger solution was increased up to 250 ml during impinger cleanup and rinse. The impinger, which contained the bubble solution, was immersed in an ice bath during sampling; this prevented the solution from being evaporated as air was drawn through. These changes allowed a sample to be collected over a 24-hour period and produced a much lower detection limit.

2.10.2.7 QA/QC

QA/QC samples, field blanks, and trip blanks were collected at the site. A field blank undergoes the full handling and shipping process used for an actual sample. It is designed to detect potential sample contamination that may occur during field operation or during shipment. A trip blank detects whether samples were contaminated during shipping.

Because of the nature of canister VOC samples, a field blank cannot be taken. The trip blank consists of an evacuated canister shipped from the laboratory and then back again, evacuated, for analysis. As a result of an omission on-site, no field blanks were taken for metals or uranium. Trip blanks for these parameters were sent at a later date directly from WESTON's office in West Chester, Pennsylvania, to the analytical



laboratory. Trip blanks were used to determine whether any contamination was present in the sample container itself. Table 2-12 summarizes all QA/QC samples.

2.10.2.8 Calibration

All TSP, PM-10, and PUF samplers were initially calibrated prior to use and did not require recalibration. Daily temperature and pressure data along with the initial calibration data were used to correct the flow rate to standard conditions. The cyanide sampling system was calibrated at the beginning and end of each sample period with a bubble tube. The flow rates were then averaged to determine flow rate for the sample period. The denuder system was designed with a flow totalizer that recorded total sample volume and did not require calibration. The canister sampling system does not require calibration. The only requirement is that the flow remain consistent over the sample period. Flow is monitored by a mass flow controller.

2.11 CONTAINER INVESTIGATION

2.11.1 OBJECTIVES

The objectives of the Phase 2 container investigation program were as follows:

- To locate liquid/sediment containers (cisterns, sumps, tanks, basins, and dry wells) at the site.
- To discern whether any of the containers qualify as USTs.
- To sample the sediments and/or liquids in these containers for a number of contaminants related to past and present site activities.

2.11.2 CONTAINER INVESTIGATION

As part of the Phase 2 investigation of potential source areas, a number of on-site containers, including tanks, basins, sumps, cisterns, and dry wells were investigated. During the Phase 1 RI activities, a number of these containers were discovered, including the large cistern beneath Building 313C.

At the start of Phase 2 fieldwork, a site walk-through was conducted. In the TSP, it was anticipated that no more than 18 containers would be discovered during site reconnaissance; however, as indicated in Table 2-13, 26 such containers were found. Samples of liquid and/or sediment were collected from these containers if such materials were found in sufficient quantity to sample. These samples were analyzed for TCL volatiles and semivolatiles, PCBs, TAL metals, gross alpha, gross beta, and isotopic uranium. In some instances, additional radioisotopes were analyzed for. If the amount of sample present did not permit all of these analyses, analyses were prioritized based on information regarding the past and present uses of the container, the past and present uses of other site appurtenances that may have contributed to the contents of the container, and exposure/risk data desired for that container and the surrounding



area. Table 2-14 shows the samples collected and the analyses requested for each sample. A total of 31 samples were collected from MTL containers. Tables 2-3 and 2-5 detail the sample containers, preservation, and holding times for the liquid and/or sediment samples collected. Field sample logs for the container sampling are provided in Appendix G. Appendix M provides photographs of a number of the containers sampled. Results of the Phase 2 container sampling at MTL are presented in Subsection 4.10.

Generally, liquid samples were collected as grab samples, with the sample bottle itself used for collection. In instances where the liquid surface could not be reached by hand, a polyethylene bottle was lowered by rope to collect the required samples. The liquid was then transferred to the appropriate sample bottles. In the case of volatiles, 40-mL volatile organic analysis (VOA) bottles were lowered directly into the liquid for sample collection.

2.12 REMOVAL OF OIL-CONTAMINATED SOIL

During the Phase 2 sanitary sewer investigation at MTL, WESTON personnel observed globules of black oil flowing through Manhole 113, located off the southwest corner of the tank farm in the sewer line running along North Beacon Street. Upon further investigation by WESTON and MTL personnel, the oil source was determined to be a leak from the north side of Building 227 (which contains two 25,000-gallon No. 6 fuel oil tanks). MADEP, Massachusetts Water Resources Authority (MWRA), EPA, and U.S. Coast Guard were immediately notified of the situation.

Further investigation established that the leak from Building 227 resulted from the presence of black oil in each of the steam traps on the condensate drain lines from the in-tank steam heater.

Following shutoff of the steam and disconnection of the steam traps, ENPRO Environmental Services was contracted to perform exploratory excavations at the suspected area of contamination. Throughout the excavation, the soil was monitored using a photoionization detector (PID). It was found that one of the condensate lines emptied into the sanitary sewer system in the vicinity of Building 227. This connection was removed. Further investigation revealed a leaking oil line, which was removed. Excavation was continued to a depth of 14 ft, at which point the entire north wall of Building 227 and an area 13 ft below the foundation were exposed. At 14 ft, elevated PID readings were still present; however, it was determined that further excavation could not occur without structural damage to Building 227, so excavation was discontinued. Soil samples were collected from each of three excavations and analyzed for total petroleum hydrocarbons (TPH) and a variety of organics found in gasolines and fuel oils. Results indicate the presence of a heavy fuel oil. The excavation was then backfilled with clean fill with permission of MADEP.

Approximately 177.4 tons of contaminated soil, 25 tons of asphalt, 430 gallons of waste oil, and 1,500 pounds of oily solids were disposed of by CYN Oil in accordance with federal and state environmental regulations. The soil from the three stockpiles was



shipped to Trimount Bituminous Product Co., in Stoughton, Massachusetts. The waste oil and oily solids were sent to Jet-line Services for recycling. The sewer line between Manholes 227 and 76 was cleaned, and the abandoned sewer line running southwest from Building 227 was cleaned and sealed off. Figure 2-2 depicts the leak area and the areas remediated.

Plans are currently underway for further remediation of the area.

2.13 TUNNEL INVESTIGATION

During the Phase 2 sampling activities, WESTON personnel conducted walk-through visual inspections of several of the tunnels underlying MTL. During the inspection, general conditions of the tunnel walls and the piping within the tunnels were noted. A complete inventory of the type, number, sizes, and condition of each pipe within the tunnel was not conducted. A map of the tunnel system is provided in Figure 2-3. The tunnel segments that were inspected are denoted by shading. The tunnel segments WESTON personnel were able to walk through are as follows:

- The segment running from Building 36 under the parking lot to Building 60.
- The segment running from the northeast corner of Building 60 northward past the western ends of Buildings 37 and 313, terminating at the southwest corner of Building 43.
- A short (less than 30 ft) section running from Building 36 northwest toward Building 311.
- A portion of the southern east-west tunnel beneath Building 39 (a sump in this tunnel was sampled—see Subsection 2.11).
- A portion of the tunnel connecting the northern and southern east-west tunnels beneath Building 39.

Within each tunnel, a number of oil and steam lines were noted, mostly of the 2½-inchor 4-inch-diameter variety. Many of the steam lines were wrapped with asbestos and, in some cases (between Buildings 60 and 43 and beneath Building 39), the asbestos was in poor condition and was falling off the pipes.

Between Buildings 36 and 311, a great deal of water was encountered on the floor, although the concrete walls and ceiling of the tunnel appeared dry and in good condition. In some areas, the water reached 6 to 8 inches in depth.

Between Building 60 and Building 43, the tunnel walls, floor, and ceiling appeared to be intact with no sign of leakage or infiltration. The steam pipes' insulation appeared to be asbestos-wrapped and in good condition. While this tunnel was very warm and humid, no pooled water was noted on the floor.



Between Buildings 36 and 60, the tunnel appeared to be completely intact. No pooled water was present, and the walls and ceiling had no noticeable cracks, holes, or discoloration. Painted portions of the tunnel appeared to be peeling in some areas. Loose white insulation material resembling asbestos was noted hanging from pipes in this tunnel. At the junction of this tunnel with another short tunnel extending northwest toward Building 97, a careful inspection of the walls and ceilings was conducted. This junction occurs at Building 227, which houses two 25,000-gallon No. 6 fuel oil tanks. An oil leak was reported to have occurred from Building 227 in the early 1970s. An inspection in 1979 revealed that the walls of the tunnel at this junction were "weeping" oil (USATHAMA, 1980). No such weeping oil was noted during Phase 2. Photographs of this junction are provided in Appendix M.

In the tunnel system beneath Building 39 (which apparently is not connected to the "main" tunnel system originating at Building 60), there was not enough headspace to walk upright, and in many cases, the tunnels were impassable; however, most of the southern east-west tunnel was observed, as was much of the north-south tunnel. A sump was noted in the southern tunnel, from which a water sample was collected. This is discussed in Subsection 2.11. A photograph of the sump is presented in Appendix M.

Generally, the tunnels inspected were in good condition and presented no apparent environmental problems; however, if the tunnels are to remain in place, the asbestos should be removed and human access restricted.

2.14 FIELD-GENERATED WASTE MANAGEMENT

2.14.1 ENVIRONMENTAL MEDIA

Outdoor field-generated wastes, such as drilling cuttings and water used for equipment decontamination, were drummed on-site and placed in a central staging area. A waste removal subcontractor then retrieved the drums and disposed of them at a hazardous waste facility. The subcontractor for waste disposal was Clean Harbors, Inc., of Boston, Massachusetts. Drums containing soils and PPE were disposed of as hazardous waste. Liquids were collected in a large tank at the Clean Harbors facility and then transported to the company's Baltimore facility for treatment. Several sanitary sewer samples contained radioactivity that exceeded background levels. Sediments from these sewer lines were collected and were disposed of as low-level radioactive waste. Radiological readings of the other outdoor wastes were not indicative of mixed waste.

2.14.2 WASTES FROM INDOOR INVESTIGATIONS

Wastes generated as a result of indoor investigations were also drummed, but since many of these wastes had the potential for radiological contamination, they were staged in a predesignated area of the site that was set aside for that purpose. These wastes include any residues, rinsates, or contaminated equipment associated with the indoor contamination study, cuttings, and liquid from intrusive activities within radiologically contaminated buildings and unused portions of analytical samples returned to the site by the laboratory because of radiological contamination. In addition, radiologically



contaminated samples were returned by the laboratories to MTL for disposal along with the drums already collected. These drums were disposed at either a low-level radioactive or a mixed waste disposal facility.

2.15 ARCHAEOLOGICAL INVESTIGATION

2.15.1 OBJECTIVES

The objectives of the archaeological investigation conducted during the Phase 2 investigation at MTL were as follows:

- To provide accurate archaeological logs of the soil borings advanced at MTL during the Phase 2 subsurface investigation.
- To ensure that areas thought to be of archaeological or historical significance were not disturbed.
- To ensure that when drilling was conducted in such areas, any artifacts uncovered could be properly extracted, catalogued, and preserved and that no artifacts would be destroyed.
- To identify, through observation of the extracted cores, historic and prehistoric sites at MTL.

The archaeological component of the Phase 2 investigation was intended to supplement previous archaeological studies, most notably the <u>Historic and Prehistoric Reconnaissance Survey</u>, Army Materials Technology Laboratory, Watertown, <u>Massachusetts</u>, conducted by the Public Archaeology Laboratory (PAL). This survey established a number of areas at MTL where potentially significant archaeological resources are vulnerable to various levels of future ground disturbance (Roberts, 1992).

2.15.2 FIELD ACTIVITIES

During the soil boring activities conducted by WESTON from 8 October 1991 to 11 December 1991, each core sample was monitored by an archaeologist (from John Milner Associates, subcontractor to Timelines, Inc.) trained in the identification of glacial soils (Roberts, 1992). As each split-spoon core sample was extracted, it was described in terms of soil color by both the WESTON geologist and the on-site archaeologist (see Subsection 2.3 for a description of the actual boring methodologies). They logged their descriptions independently of one another. In those instances where artifacts were recovered, they were cleaned and catalogued by Timelines. The on-site archaeologists maintained field notes for each borehole.

During the drilling activities, attempts were made to assess the integrity of the recovered soil profile. Before this could be accomplished, a "normal" soil profile was established as a baseline against which all other site profiles could be compared. The boring established as the "normal" profile was 02SB-3 (for details, see Roberts, 1992).



Based on drilling logs maintained during the drilling activities and on comparisons among the site borings and the "normal" soil profile established in 02SB-3, an attempt was made to identify the known historic and prehistoric sites. It was not possible to identify the location of the prehistoric site, since the boring closest to the suspected prehistoric site showed no evidence of prehistoric activity. Two known historic sites (at 01SB-1 and GRSB-17) were tentatively identified based on the presence of artifacts, but these locations could not be confirmed with the information available. It is believed that test excavations would be needed for confirmation.

Based on the boring logs, fill areas throughout the site were identified (for the Timelines definition of "fill," see Roberts, 1992). Based on analyses of the fill material sitewide, an archaeological potential was established for each boring. "Archaeological potential" essentially represents the probability that the soil in any given area will contain historic or prehistoric resources. Information on the depth of any given area, together with the archaeological potential for that area, was used to estimate the vulnerability of existing archaeological resources. Essentially, those cores with high archaeological potential and a relatively thin fill covering were classified as more vulnerable than high-potential cores possessing a very thick fill layer. Therefore, by overlaying a stratigraphic map depicting fill depths across the site with a similar type of map depicting archaeological potentials, a stratigraphic representation of sitewide archaeological vulnerability could be produced. WESTON borings 01SB-2, 02SB-3, 09SB-1, 10SB-2, 11SB-1, 11SB-2, 11SB-4, 12SB-1, 12SB-2, 13SB-2, 13SB-3, 14SB-1, 15SB-2, 17SB-1, 17SB-2, GRSB-2, GRSB-7, GRSB-11, GRSB-15, GRSB-17, GRSB-19, and GRSB-21 exhibited high archaeological potential. Of these, 01SB-2, 02SB-03, 09SB-1, 11SB-4, 13SB-2, 13SB-3, GRSB-2, GRSB-11, GRSB-15, and GRSB-17 are the most vulnerable. Figure 2-4 illustrates the stratigraphic representation of archaeological vulnerability across the facility. The most vulnerable portion of the site (based on vulnerability index) is the soil in the eastern area near Buildings 131 and 111. A few small patches of highly vulnerable soils were also identified along the northern fence line at either end of Building 311.

The archaeological report on the MTL soil borings is presented in Appendix K.

Section 3 Physical Characterization



PHYSICAL CHARACTERIZATION

The information in this section provides literature and RI data regarding the environmental setting of MTL and its surroundings. This section is intended to provide the reader with a background and perspective from which to view the results of the RI and also to familiarize the reader with the contexts in which the investigation was designed. The findings of the geologic and hydrogeologic investigation of the RI (except chemical data) are also presented.

3.1 TOPOGRAPHY AND LAND USE

MTL is located within the greater Boston metropolitan area, in an urbanized area of Watertown, Massachusetts, on the north bank of the Charles River. The site and surrounding area are generally flat, decreasing in elevation from approximately 36 ft above mean sea level (MSL) along the northern boundary of the facility to approximately 2.4 ft MSL at the edge of the Charles River (Figure 3-1). The major portion of the MTL facility is situated on a low bluff approximately 25 to 35 ft above MSL, which drops off sharply just north of North Beacon Street to an elevation of approximately 15 ft above MSL. In general, most of the buildings and parking lots are located on the northern portion of this bluff, which then slopes down to a grassy, undeveloped park area adjacent to the Charles River south of North Beacon Street.

The original, glacially formed land surface has been extensively altered by more than a century of construction, demolition, and modification of buildings, roadways, and other structures in and around the MTL facility. Most, if not all, of the original topography has been covered by fill, which consists of sand and gravel and construction debris used to level the site area for the construction of buildings, parking lots, and other supporting structures.

The present active MTL facility covers approximately 36.5 acres of land, bounded by Arsenal Street to the north, North Beacon Street to the south, commercial property to the west, and a condominium complex and small park to the east. The 11-acre area of land between North Beacon Street and the Charles River has been out-granted to the Commonwealth of Massachusetts and includes a park and marina. Approximately 55 acres of land to the east of the present MTL facility were excessed by the U.S. Government prior to 1968.

MTL is zoned for open space/conservancy (Cartographic Associates, 1989). This zoning reflects the classification to which the property would revert if sold to a nonfederal agency. The Commander's Quarters on MTL is on the National Register of Historic Places, and the facility itself has been declared an historic district.



3.2 CLIMATE

The climate of MTL and the Boston area is affected by three major factors. First, Boston is located in a zone of prevailing west-to-east atmospheric flow. Second, Boston is situated on or near several paths that are frequently followed by low-pressure storm systems, and both polar and tropical air masses can exert an influence on the region. Finally, temperatures are moderated by the proximity of the Atlantic Ocean, although the distance from Watertown to the coast reduces this maritime effect. The freeze-free period typically ranges from early April to early November, but the inland location may shorten the freeze-free period by a week or two in the spring and a week or two in the fall.

Daytime maximum temperatures throughout the summer are generally in the 70s, with the warmest temperatures occurring in July. The mean temperature for July is 72.7 °F, with recorded extremes ranging from a high of 102 °F in 1977 to a low of 54 °F in 1986. Daytime minimum temperatures are lowest in January and exhibit a mean of 28.6 °F, with a highest recorded extreme of 63 °F in 1974 and a lowest recorded extreme of -12 °F in 1954. All of these climatic data were collected at the meteorological station at Logan International Airport, located approximately 8 miles east of MTL.

Low-pressure systems regularly pass through the region, producing precipitation approximately one day in every three. Data from 1958 through 1988 indicate a mean annual precipitation for Boston of 41.6 inches, with maximum and minimum monthly means of 3.89 inches in November and 3.12 inches in July.

The average annual wind speed for 1987 was approximately 12.4 miles per hour. The most prevalent wind direction is from the southwest, except during the months of December through March, when northwesterly winds prevail in conjunction with arctic airflow from Canada. Winds of 30 miles per hour or higher may be expected at least one day in every month. A wind rose for Logan International Airport for the period 1985 to 1989 is presented in Figures 3-2 and 3-3.

3.3 SURFACE HYDROLOGY

As stated in Subsection 3.1, the MTL site slopes approximately 20 ft from the northern portion of the site to the southern boundary. Therefore, the natural drainage pattern that surface runoff would follow is north to south towards the Charles River. The major segments of the stormwater collection system follow this natural drainage pattern. The majority of the minor segments, which are responsible for conveying surface runoff from cisterns and catch basins located throughout the site to the major segments of the stormwater collection system, generally run in an east-to-west direction.

One major segment of the stormwater collection system bisects the site just east of Building 656. This segment originates off-site north of Arsenal Street, enters the site on the north side of Building 311, travels southward between Buildings 656 and 292, and exits the site at the intersection of North Beacon Street and Charles River Road.



A monitoring location (Background 1) was placed at the manhole north of Building 311 where this segment first enters the site. A second monitoring location (Outfall 1) was located on this segment where it exits the site at the intersection of North Beacon Street and Charles River Road. This was done to determine the net increase of flow and chemical parameters, contributed by the MTL site, that would occur during a precipitation event.

The majority of surface runoff that is conveyed across the MTL site exits the site through Outfalls 1, 2, and 5.

3.4 BEDROCK GEOLOGY

3.4.1 REGIONAL GEOLOGY

The MTL facility is located within the central portion of the Boston Basin, a structurally bounded depression in Precambrian basement rock that was subsequently filled in with Cambrian-Devonian intrusive rocks (Blue Hills Block), Mississippian volcanic rocks (Mattapan Complex and Lynn Complex), and Pennsylvanian sedimentary rocks (Boston Basin Group: Cambridge Argillite and Roxbury Conglomerate) (LaForge, 1932; Billings, 1976; Kaye, 1980). A bedrock geologic map for the Boston Basin is provided in Figure 3-4.

The basin is bounded to the north and northwest by the Northern Boundary Fault, a thrust fault that forms a low-angle contact between Pennsylvanian-age Cambridge Argillite and Precambrian-age basement rocks. To the west of the site, the basin fill rocks are truncated by high-angle normal faulting. To the south of the site, the Mt. Hope, Blue Hills, and Ponkapoag thrust faults form low-angle contacts between basin fill rocks and Precambrian basement rocks. Finally, the east margin of the basin is located beneath Massachusetts Bay (Billings, 1976).

The Precambrian basement rocks have been crosscut at several locations by Cambrian-Devonian intrusive and Mississippian volcanic rocks. To the south, between the Ponkapoag and the Blue Hills thrust faults, the basement rocks are intruded by the Cambrian-Devonian age peralkaline (sodium- and potassium-rich) Blue Hills Complex. The Blue Hills Complex includes the Quincy Granite and other felsic (silica-rich) intrusions. In the southwest portion of the basin, altered felsic and basaltic volcanics of the Mississippian-age Mattapan Complex are exposed. Volcanic rocks of similar composition assigned to the Mississippian-age Lynn Complex are exposed north of the Northern Boundary Fault. Both volcanic complexes crosscut the Precambrian basement rock and are included as clasts in the Pennsylvanian-age Boston Basin sedimentary rocks (LaForge, 1932).

The Boston Basin Group consists of two formations, the lower Roxbury Conglomerate and the upper Cambridge Argillite. LaForge (1932) subdivided the Roxbury Conglomerate into three members: the Squantum, Dorchester, and Brookline members. In general, the Roxbury conglomerate outcrops south of the Charles River and the Cambridge Argillite outcrops north of the Charles River (Kaye, 1982).



The Cambridge Argillite is typically a varved (rhythmically layered) siltstone. Beds range in thickness from 0.1 to 8 cm (0.04 to 3.1 inches) and vary from dark gray clay and silt-rich layers to light gray fine- and very fine-grained sand layers. Sedimentary structures such as graded beds, cross-bedding, ripple marks, and slump structures have been observed in the rock.

3.4.1.1 Structural Geology

The internal structure of the Boston Basin Group consists of a series of broad folds, plunging gently to the northeast and east (Billings, 1976). Most of the fault zones in the basin trend northeast, including the bounding thrust faults. The only major exceptions to this are the Stony Brook Fault and an unnamed fault at the southwest margin of the basin, both of which are high-angle faults and trend north-northeast and north-northwest, respectively. The Stony Brook Fault is mapped from Fresh Pond, approximately 2 miles east of the MTL, and runs south-southeast for approximately 20 miles.

The MTL site is located on the northern arm of the Charles River syncline, one of the broad folds within the Boston Basin Group. The syncline axis has an east-west orientation and is located beneath the channel of the Charles River as it flows by the MTL site. The syncline has subsequently been filled in with Quaternary and recently deposited unconsolidated sediments. At the point where the Charles River flows past the site, the syncline axis is believed to reach a maximum depth of up to 190 ft bgs (Chute, 1959).

3.4.2 SITE-SPECIFIC BEDROCK GEOLOGY

Based on mapping conducted by Billings (1976), the Pennsylvanian-age Cambridge Argillite underlies the entire MTL facility. Geophysical results from a seismic refraction survey conducted by Weston Geophysical Corporation of Weston, Massachusetts (not affiliated with Roy F. Weston, Inc.), during the Phase 1 RI were used to estimate depths to bedrock and construct a bedrock contour map (Figure 3-4). Based on the seismic survey, depth to bedrock was believed to range from slightly less than 50 ft to approximately 140 ft.

Prior to the start of the Phase 2 study, little soil boring information providing confirmed depths to bedrock was available. In 1985, Goldberg-Zoino Associates, Inc. (GZA), of Newton, Massachusetts, completed eight soil borings in a parking lot south of Building 36. The borings were to be used to provide geotechnical information for a proposed research facility that was never built. Bedrock was not encountered in any of the borings; however, two borings were drilled to approximately 80 ft without encountering refusal, indicating that depth to bedrock in this area is at least 80 ft. This result supports the Phase 1 geophysical work, which suggests that depth to bedrock in this area is in the 80-to-95-ft range. During the Phase 1 RI, one well, C-1, encountered bedrock at 61.5 ft. This depth to bedrock closely agreed with the 57-ft depth that was projected based on geophysical survey results.



During the Phase 2 RI, four on-site wells, MW-21, MW-15A, MW-17A, and MW-19A, encountered refusal that was assumed to be bedrock. With the exception of MW-19A, all refusal depths agreed to within 5 to 10 ft of the depths projected based on the Phase 1 geophysical study. MW-19A was drilled in what is believed to be (based on geophysics) the area of the deepest bedrock on the site. Phase 1 geophysical results had suggested that depth to bedrock in this area is in the 140-ft range, although rock was encountered in MW-19A at 98 ft bgs. Bedrock at MW-19A was confirmed by drilling an additional 14 ft through rock with an air hammer. This drilling result indicates that the geophysical survey overestimates the depth to bedrock in this portion of the site. One off-site well, MW-16A, encountered rock refusal at 41 ft, suggesting that the depth to bedrock decreases to the northwest moving away from the site. This drilling result agrees with surficial geologic mapping (Chute, 1959), which reports thinning and eventual loss to the outwash and the clay/fine sand layers moving northeast from the site.

Based on drilling results from the Phase 2 RI and on Phase 1 RI geophysics, estimates of depths to bedrock are provided in Figure 3-5. These estimates assume that the general shape of the bedrock surface determined by geophysics is correct; however, adjustments of depth to bedrock were made based on bedrock depths confirmed by Phase 2 drilling.

Based on a rock coring obtained at boring C-1 during the Phase 1 RI, the Cambridge Argillite beneath the site was described as follows:

The recovered core from the Cambridge Argillite shows that it is highly folded beneath the MTL. The drill core axis is nearly parallel to the bedding in the drill core sample, indicating the originally horizontal bedding has folded to a vertical orientation (EG&G, 1990).

3.5 SOIL AND SURFICIAL GEOLOGY

3.5.1 REGIONAL SURFICIAL GEOLOGY

The unconsolidated materials within and surrounding the MTL site were deposited as a result of glacial activity primarily during the advance and retreat of the last ice sheet that covered the region (Chute, 1959). The sequence of sediments includes glacial till, lake deposits composed of clay interbedded with some fine sand and gravel, outwash deposits of sand and gravel with some fine material, and recent deposits.

The sequence of unconsolidated sediments can best be understood by taking into consideration the history of the most recent glacial event that took place in this region. The oldest unconsolidated material is a lodgement till laid down during the advance of this most recent ice sheet. The till is believed to consist of a thin veneer of poorly sorted material with thicker deposits in valleys. On a regional scale, little is known about the thickness and distribution of the till, and it may even be absent in some areas. The thickness of this deposit is a function of postdeposition erosion activity.



Following retreat of the ice sheet, ponded meltwater filled in low-lying areas and deposited clay with some sand and gravel mixed in. Deposition ended when a short readvancement of the ice sheet caused ponded water to drain. As the ice sheet readvanced, it also scraped up the fine-grained deposits, thereby forming the Fresh Pond Moraine, an end moraine located approximately 1 mile northeast of the site. The MTL site is located downgradient of the end moraine, and in this area, the fine-grained materials were not removed by the readvancing ice. In front of the advancing ice sheet, sand and gravel and, to a lesser extent, minor quantities of fine-grained material were deposited as outwash on top of the previous fine-grained meltwater deposits. Deposited on top of the outwash are sandy and silty loam, fill material, and peat, each a result of postglacial activity.

The soil at MTL is classified by the Soil Conservation Service as Merrimack gravelly sandy loam, although the entire area falls generally within an "urban land" designation. Soils at MTL have been extensively altered during the history of the facility by various construction activities. It is difficult to find sections of native soil because of extensive excavation and backfilling at the site.

3.5.2 SITE-SPECIFIC SURFICIAL GEOLOGY

The surficial geology at MTL has been investigated since 1958, first for its water supply potential, which is described in two reports (NED, 1958; Layne, 1958). More recently, in 1987, GZA completed a geotechnical study to investigate a parking lot adjacent to Building 36. A total of eight borings were completed. The most recent geologic and hydrogeologic work has focused on assessing soil and groundwater contamination resulting from activities at the MTL facility.

In general, the overburden deposits consist of (in ascending order) basal glacial till directly overlying bedrock, silty clay with some fine sand and gravel, interlayered outwash deposits of sand and gravel with some fine materials, and finally, more recent deposits and fill near the surface.

Based on soil boring and geophysical information, the total thickness of these unconsolidated materials is thought to range from just under 50 ft near the northwest corner of the site to approximately 95 ft in the area near MW-19A on the eastern side of site. Rock refusal was encountered in MW-16A at 41 ft bgs, indicating that unconsolidated material becomes thinner moving off-site to the northwest. Moving south off the site towards the Charles River, no deep wells or borings were completed near the Charles River; however, depth to bedrock is thought to increase approaching the axis of the Charles River syncline (Chute, 1959).

Based on field observation from soil boring results, the distribution of surficial units at MTL was found to be highly variable; however, it is possible to characterize changes in thickness and distribution of geologic material. Based on both Phase 1 and Phase 2 soil boring logs, two geologic cross-sections were constructed to illustrate the distribution and thicknesses of surficial geologic units at MTL (Figures 3-6, 3-7, and

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3-8). A discussion of the distribution of unconsolidated materials as observed in cross-sections is provided below.

During previous studies, the lowest stratigraphic unit (glacial till) was encountered in three soil borings at the site (C-1, C-3, and B-6) and fully penetrated only one boring, C-1. In boring C-1, the till was approximately 8 ft thick and was encountered at a depth of 61 ft. Although no split-spoon samples were retrieved from boring C-1, drilling cuttings included surrounded cobbles of granitic bedrock and subangular fragments of Cambridge Argillite. In boring C-3, the till consisted of gray-green silt-rich gravel with angular rock fragments and medium- to coarse-grained sand. Although the boring penetrated only 2 ft into till at this location, from a depth of 37.5 to 39.5 ft, the till thickness was inferred by previous investigators (EG&G, 1990) to be approximately 25 ft, based on the seismic refraction profiles. In boring B-6, 2 ft of glacial till consisting of a dense brown clayey, silty sand with gravel was penetrated from a depth of 76 to 78 ft.

During the Phase 2 RI, all six deep monitor wells (MW-15A, MW-16A, MW-17A, MW-19A, MW-20, and MW-21) encountered till, with thicknesses ranging from 7 to 42 ft. The 42-ft thickness was reported at MW-19A, where Phase 1 seismic refraction results suggest that a bedrock trough exists. Composition of till ranged from predominantly clay and silt, with low percentages of sand and gravel (MW-15A and MW-17A), to between 30 and 50% sand and gravel, with low percentages of clay and silt, at the eastern end of the site (MW-19A and MW-20). Deep wells located in the middle and western portions of the site (MW-15A, MW-17A, and MW-21) showed slow recharge rates and were typically pumped dry during well development. Deep wells on the eastern end of the site (MW-19A and MW-20) showed quicker recharge rates and were not pumped dry during well development.

Above the glacial till deposits, which appear, based on soil boring logs, to be continuous over the entire site, a predominantly silt and clay unit was encountered in all but four borings. This material is presumed to have been deposited by ponded meltwater that accumulated during retreat of the most recent ice sheet. The silty sand was not encountered at the eastern edge of the site in MW-7 and MW-8, which were installed during the Phase 1 RI, or in MW-19A and MW-20. The fine-grained meltwater deposits range in thickness from nonexistent to 58 ft in MW-17A. It is difficult to conclude with absolute certainty why the meltwater deposits become thinner and eventually disappear moving to the east. This disappearance is possibly the result of postdepositional erosion that may have occurred during deposition of upper sand and gravel outwash deposits. Cobbles and coarse sand were reported at the eastern end of the site within the outwash. This indicates that at some point during deposition of outwash, water velocities were very high. In general, the full thickness of this unit is water-saturated, except in the northern third of the site, where the upper 5 to 10 ft of the silty sand may be unsaturated, as indicated by the groundwater levels shown on the geologic crosssections.

Above the fine-grained meltwater deposit, a sand unit was encountered across the site. Absent from the northwestern corner of the site, as shown by boring logs MW-10, C-1,



and MW-14, this unit becomes thicker and generally coarser grained towards the east. It is characterized as a fine-to-coarse sand and gravel, with cobbles also present on the eastern portion of the site. This unit is the outwash deposit that was laid down during the advance of the most recent ice sheet.

Above Quaternary deposits at the southeastern boring location C-3, and at borings located on the south side of Beacon Street, peat was encountered above the silty sand unit. This is believed to represent a buried swamp previously adjacent to a former channel of the Charles River. Other borings (MW-6 and MW-11) constructed at the same elevation as C-3 with respect to the Charles River did not encounter peat, further suggesting that the peat deposits are probably limited in areal extent.

Fill material with widely varying characteristics is found over the entire site. The fill ranges from fine sand to coarse sand and gravel, with building debris (bricks, concrete, cinders or slag, and wood) mixed in at a number of locations. The fill is reported to range in thickness from a few feet to approximately 20 ft (at MW-4). Typically, fill was interpreted to be in the 5-to-8-ft-thick range, which is consistent with most of the foundation design requirements for structures at MTL. At many locations, however, fill was difficult to distinguish from the underlying outwash, particularly along eastern and southern portions of the site where both the native and fill materials consist of medium-to-coarse sand and gravel.

3.6 HYDROGEOLOGY

Interpretation of hydrologic conditions at MTL is based on analysis of geologic and hydrologic data from soil borings and monitor well installations, water-level measurement data, and aquifer hydraulic conductivity test results (slug tests). The hydrogeologic setting determines the occurrence and migration of groundwater and is a fundamental factor influencing installation water quality.

3.6.1 REGIONAL HYDROGEOLOGY

Sufficient information exists to discuss relationships only within the unconsolidated glacial sediments at MTL. While it is recognized that the underlying bedrock (Cambridge Argillite) is probably a separate hydrologic unit, there is little hydrogeologic information available on the bedrock. Based on the geologic setting, the fact that several reservoirs in the MWRA compose the source of public water supply, and the urbanized environment in which the MTL site is located, it is probable that groundwater occurrence and flow within bedrock is of limited significance in relation to human or ecological receptors. Therefore, hydrogeologic properties of the bedrock will not be evaluated as part of the assessment of site hydrology.

The MTL site is located on the northern limb of the Charles River syncline, a buried valley that forms the channel for the Charles River as it flows past the site. Topographically, land surface elevations increase traveling away from the site to the north and to the south on the opposite side of the Charles River (Figure 1-2, Topographic Map). Investigation results indicate that regional hydrology is generally



controlled by the physiographic setting, with regional groundwater flow away from the topographic high areas and towards the Charles River. On the northern side of the Charles River, regional groundwater flows generally in a southerly direction across the site towards the river. On the southern side of the Charles River, regional groundwater is believed to flow generally in a northerly direction, also towards the river.

3.6.2 SITE-SPECIFIC HYDROGEOLOGY

Water-level measurements collected for the Phase 2 work were used to characterize groundwater conditions. Based on these measurements, piezometric surface contour maps were developed for shallow and deep wells. Water-level data are summarized in Table 3-1. Data collected over several months during the Phase 1 study were used to evaluate seasonal variations in water levels.

3.6.2.1 Water Table Configuration

In general, depth to groundwater is within 5 to 10 ft of the land surface along the southeastern boundary of the facility adjacent to the Charles River. Depth to groundwater reaches a maximum of approximately 30 ft bgs along the eastern boundary of the site, where the ground surface reaches its maximum elevation and coarse-grained deposits allow rapid soil drainage. Depth to groundwater in the central portion of the facility is on the order of 15 to 20 ft bgs for shallow wells and 20 to 25 ft bgs for deep (A-series) wells.

Variations in groundwater flow direction and velocity may occur as a result of fluctuations in water level. Groundwater data collected monthly between 8 February 1990 and 31 August 1990 as part of the Phase 1 RI were used to assess seasonal variations in groundwater flow. The groundwater data indicate that flow paths across the site are not significantly influenced by seasonal variations in groundwater level. Groundwater elevations were generally lower for summer months (resulting from lower recharge during the summer); however, lower groundwater levels were consistent throughout the entire site and, as a result, there was little significant change in flow direction or horizontal hydraulic gradient. Because the historical groundwater data used to establish seasonal trends were collected before installation of well couplets, no seasonal assessment of seasonal variations in vertical hydraulic gradient could be made.

Groundwater data collected for the Phase 2 RI were used to develop separate piezometric surface contour maps for the deep and shallow wells at the site (Figures 3-9 and 3-10). Phase 2 data made use of 15 additional wells (31 wells total), which provided greater detail on groundwater flow in the following areas:

- Along the upgradient (northern) boundary of the site
- Along the downgradient (southern) boundary of the site
- Within the deeper groundwater immediately above bedrock

As shown in the piezometric surface maps for both shallow and deep wells, the general groundwater flow direction is south-southeast towards the Charles River. Groundwater

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was expected to flow in this direction based on the regional physiographic setting. Approaching the river, groundwater contours within shallow wells generally parallel the north bank of the Charles River, clearly showing that the river is influencing shallow groundwater flow. In addition, the surveyed river water elevation is lower than the surrounding groundwater elevation in the Charles River, indicating that the hydraulic gradient drives shallow groundwater into the river.

In the northwest portion of the study area, along Arsenal Street, water-level data suggest local mounding is creating a groundwater flow component towards the north. The three rounds of water-level measurements collected in December 1991, and January and March 1992, as part of the Phase 2 RI, showed differences in the degree of groundwater mounding occurring. Mounding was greatest in December 1991, probably due to heavy rainfall that occurred during that time period. Water-level measurements collected in January and March of 1992 show less mounding in the northwest portion of the study area. The groundwater contour map indicates the mound runs in a roughly linear, east-west orientation. Although the exact location of the crest of the mound is not known, two possible locations for the mound have been considered. The first potential location is south of wells MW-10 and MW-13 along the northwest corner of the site. If this is where the mound is located, then contaminants generated in the northwest corner of the site, including inside Buildings 246 and 311, could potentially migrate off-site to the north, towards what were previously identified as upgradient wells MW-24, MW-16, and MW-16A. This mound configuration is unlikely for the following reasons:

- It is difficult to develop a reasonable groundwater contour map with the crest of the mound located south of wells MW-10 and MW-13. The hydraulic gradient between the crest of the mound and downgradient well MW-14 (where the water level was measured at 19.6 ft in December 1991) would be extremely steep, much steeper than in any other part of the study area.
- The ground surface in this area is covered by Building 311 and by an asphalt parking lot located west of 311; therefore, overhead precipitation recharge to maintain the mound will not occur.

An alternative groundwater mound location is north of wells MW-10 and MW-13 along Arsenal Street. This location is a more likely for the following reasons:

- It is much easier to develop a plausible groundwater contour map with a mound located in this area. Hydraulic gradients encountered would not be unreasonably steep as was the case when assuming a mound location south of wells MW-10 and MW-13.
- Surface cover in this area consists of grass, which would allow for infiltration of overhead recharge; underground utility pipes running along Arsenal Street provide another potential source of groundwater recharge.



Because the probable location of the peak of the mound observed in the northwest portion of the study area is north of wells MW-10 and MW-13, no opportunity exists for contamination from on-site sources, particularly in Building 311, to migrate off-site northward towards areas identified as upgradient.

Within deep wells, groundwater contours show that flow is again to the southeast towards the river; however, because there are fewer deep wells available, the exact shape of the deep groundwater contours as they approach the Charles River is not clearly understood. As a result, it is difficult to conclude with certainty how the river affects deep groundwater flow and whether deep groundwater is flowing into the river or is continuing to flow in a southeast direction beneath the river, eventually ending up in Boston Harbor.

3.6.2.2 Hydraulic Gradients

A comparison of water-level measurements across the site was used to assess both horizontal and vertical hydraulic gradients. Vertical gradients were evaluated by comparing shallow and deep water elevations at well clusters in the following locations: MW-15/MW-15A, MW-16/MW-16A, MW-17/MW-17A, MW-8/MW-20, and MW-19/MW-19A.

Using the equation that shows that hydraulic gradient is equal to the ratio of change in head between two points to distance between those two points, vertical hydraulic gradients have been calculated between shallow and deep well screens for each well cluster. Vertical groundwater flow gradients are presented for each well cluster in Table 3-2.

In general, at the time water-level measurements were collected, water levels in shallow wells were several feet higher than in complementary deep wells. This indicates that a strong downward vertical gradient exists over most of the site. This situation provides a potential for contaminated shallow groundwater to migrate to the deeper zone. An exception to this general strong downward hydraulic gradient is the eastern portion of the site, where the head in the shallow and deep wells is nearly equal, indicating that flow between the shallow and deep groundwater is less restricted in this area than in other portions of the site.

The reason for the low vertical gradient in the eastern portion of the site is related to the coarse-grained materials found throughout the stratigraphic column. The coarse-grained materials allow for good hydraulic connection between the shallow and deep sediments, and the head in sediments is therefore nearly equal. For the remainder of the site, the opposite is true. Deep, low-conductivity fine sediments act as a barrier that impedes downward groundwater percolation. During wet periods, infiltrated water mounds in shallow sediments.

Horizontal hydraulic gradients were evaluated for both shallow and deep monitor wells. Gradients evaluated for shallow groundwater between the northern site boundary and the Charles River ranged from 0.010 at the eastern end of the site to 0.023 at the



western end of the site. The reason for the difference in gradients between the two ends of the site is again the difference between the hydraulic conductivities of the sediments. At the eastern end of the site, hydraulic conductivity of sediments is high, and as a result, precipitation recharge is transmitted quickly through sediments. This situation results in a relatively low amount of groundwater mounding and flat hydraulic gradients. At the western end of the site, hydraulic conductivity is low and precipitation recharge is not transmitted quickly; this causes mounding of groundwater and steep hydraulic gradients. Flow paths used to compute hydraulic gradients are identified in Figure 3-10 as Flow Path A and Flow Path B for the eastern and western ends of the site, respectively.

Within deep wells, computation of hydraulic gradient was completed for groundwater flowing south-southeast between the northern and southern boundaries of the site. Because of the limited number of wells, hydraulic gradient was computed for only one flow path (identified as Flow Path on Figure 3-9). The hydraulic gradient, computed across the site for the deep aquifer, is 0.0082.

3.6.2.3 Hydraulic Conductivity

During the Phase 1 RI, in situ hydraulic conductivity testing was performed at MW-1 through MW-14 and at monitor well C-2. In addition, laboratory hydraulic conductivity testing of soil samples collected at the following five monitor well locations was completed: C-1, C-3, MW-1, MW-2, and MW-14. Test results are summarized in Table 3-3. The following general comments may be made about the Phase 1 slug test results:

- Some of the hydraulic conductivity test results may be biased high, since testing and analysis were performed on monitor wells that were screened across the water table.
- Some wells were screened across more than one geologic unit, and as a result, conductivity results will apply to the more conductive unit.
- No hydraulic conductivity of the glacial till was obtained, as no wells from the Phase 1 RI were screened in the till.

To reduce data gaps in Phase 1 slug test results, WESTON completed a limited number of slug tests during the Phase 2 RI. Phase 2 hydraulic conductivity testing was completed at the following well cluster locations: MW-15/MW-15A, MW-16/MW-16A, MW-17/MW-17A, and MW-19/MW-19A. By using the well clusters, conductivity of till could be evaluated, and a comparison of deep versus shallow hydraulic conductivity could be made at each location.

To reduce problems associated with results biased by the presence of an unsaturated filter pack in shallow wells, slugs were placed in shallow wells and water levels in wells were allowed to recover for several hours. Following complete water-level recovery, slugs were pulled from wells, and the rate of water-level recovery was measured. For shallow wells, only the rising portion of the slug test was used. Slug test results are



presented in Appendix E, and a summary is presented in Table 3-4. Based on WESTON's slug test results, the following general comments may be made about site hydraulic conductivity:

- Hydraulic conductivity results for shallow sediments (outwash) are in the range of 0.4 to 0.9 ft/day. These values remain consistent throughout the entire site.
- Upgradient of the site, test results for MW-16 suggest that hydraulic conductivity of shallow (outwash) sediments is greater than on-site (3.9 ft/day). This conclusion is supported by observations made during development of upgradient shallow wells MW-22, MW-23, MW-24, and MW-16. In general, a greater pumping rate was used for these wells than for the shallow on-site wells. Increased conductivity (i.e., grain size) of outwash sediments traveling north from the site corresponds to the surficial geologic model of the region; coarse-grained sediments would be expected upgradient of the site because this area is believed to be closer to the original depositional source.
- Hydraulic conductivity of deep wells MW-15A and MW-17A was an order of magnitude lower than the shallow wells, ranging from 0.04 to 0.09 ft/day. MW-15A and MW-17A are screened across two formations: the upper predominantly silt and clay ponded water deposits and the lower glacial till. Slug test results would represent a composite conductivity of the two; however, the test results would be biased towards the more conductive unit. Therefore, it could be concluded that at locations MW-15A and MW-17A, the hydraulic conductivities of both silt and clay and glacial till are very low.
- Hydraulic conductivity results from MW-19A suggest that the conductivity of the deeper portion of the aquifer in the eastern portion of the site is as much as two orders of magnitude greater than deep sediments at other portions of the site. The recharge rate observed during development of MW-20 also supports the conclusion that there is increased conductivity in deep sediments on the eastern side of the site.

3.6.2.4 Groundwater Velocity and Travel Times

Based on hydraulic conductivity results for shallow monitor wells located at the downgradient (southern) MTL property boundary and hydraulic gradients computed from December 1991 monitor well water-level measurements, flow paths between shallow wells MW-1, MW-2, MW-5, MW-6, MW-11, MW-17, and MW-18 and the Charles River were determined, and groundwater travel times between each well and the river were calculated. Groundwater flow paths are shown in Figure 3-8, and travel times are summarized in Table 3-5. All hydrogeologic data used to compute travel times were obtained within the MTL facility. Therefore, travel time calculations assume that



hydrogeologic properties in the area between the site and the Charles River, for which no hydrogeologic data exist, are similar to those on the site.

Computed travel times ranged from a minimum of 0.7 years between MW-2 and the river to a maximum of 4.1 years between MW-6 and the river.

3.7 ECOLOGY

The ecological setting of MTL is described in the environmental evaluation in Section 7 of this document. A brief summary of the ecological setting is presented below.

The majority of MTL is covered by buildings or paved parking lots; however, a number of species of wildlife and vegetation still exist at the site. No endangered or threatened plant or animal species are believed to be present on or near MTL.

The Charles River is managed by the Massachusetts Department of Fisheries and Wildlife as a warm water fishery. A number of fish species inhabit the river in the vicinity of Watertown, and ducks and geese may frequent the Charles River during migration.

The most recent National Wetlands Inventory Map for the MTL area (1977) indicates no natural drainages on MTL. The nearest wetland area is an unnamed island in the Charles River immediately south of the North Beacon Street Park.

Section 4 Nature and Extent of Contamination



NATURE AND EXTENT OF CONTAMINATION

This section summarizes the data gathered through inspection, instrument surveys, geophysical surveys, dye testing, and chemical and radiological sample analyses of building interiors, cisterns, tanks, sumps, dry wells, storm and sanitary sewers, and environmental media at MTL.

For chemical and radiological analyses, comparisons to background and to ARARs are made. As described in Subsection 4.1, comparison of laboratory data to ARARs is required under CERCLA. As described in Section 1, MTL is a non-NPL/CERCLA-investigated site. Therefore, although MTL is not an NPL site, to provide a conservative approach in addressing issues of risk and site remediation, CERCLA protocols have been followed in Phase 2. To this end, comparison of site data to ARARs was performed for each of the media sampled. While a comparison to ARARs provides information regarding the degree of contamination, decisions regarding the need for remedial action will be based on the baseline risk assessment and environmental evaluation (Sections 6 and 7, respectively).

The data tables used when discussing the data presented in Section 4 contain only detected parameters. Therefore, omissions of compounds from the tables does not indicate the parameter was not analyzed. Refer to the appropriate sections in Sections 2 and 4 to determine which samples were analyzed for which parameters. In discussing the data in Section 4, parameters that were reported with greater-than values are presented. When the reported greater-than value is below a particular ARAR, it is presented with the ARAR limit, since it can not be confirmed to be below or above the limit.

4.1 ARARs

EPA policy, as reflected in SARA and in the NCP, provides that the development and evaluation of remedial actions under CERCLA must include a comparison of alternative site responses to applicable or relevant and appropriate federal and state environmental and public health requirements.

Identification of ARARs must be conducted on a site-specific basis. Neither SARA nor the NCP provides across-the-board standards for determining whether a particular remedy will produce an adequate cleanup at a particular site. Rather, the process recognizes that each site will have unique characteristics that must be evaluated and compared to those requirements that apply under the given circumstances. Nonetheless, the remedial action selected must meet all ARARs, unless a waiver from specific requirements has been granted. Under SARA, permits are not required for CERCLA on-site activities.



ARARs are defined as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.
- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site.

ARARs may be divided into the following categories:

- <u>Chemical-specific requirements</u> are health- or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. These limits may take the form of cleanup levels or discharge levels.
- <u>Location-specific requirements</u> are restrictions on activities that are based on the characteristics of a site or its immediate environment. An example would be restrictions on wetlands development.
- <u>Action-specific requirements</u> are controls or restrictions on particular types of activities in related areas such as hazardous waste management or wastewater treatment. An example would be Resource Conservation and Recovery Act (RCRA) incineration standards.

A preliminary evaluation of chemical-specific ARARs for the MTL site is presented in Subsection 4.1.1. A comprehensive evaluation of the chemical-specific, location-specific, and action-specific ARARs for the MTL site will be presented in the MTL FS report.

In addition to legally binding laws and regulations, many federal and state environmental and public health programs also develop criteria, advisories, guidance, and proposed standards that are not legally binding, but that may provide useful information or recommended procedures. These materials to be considered, or TBCs, are not potential ARARs but are evaluated along with ARARs. TBCs for the MTL site are described in Subsection 4.1.2.

4.1.1 CHEMICAL-SPECIFIC ARARS FOR THE MTL SITE

Each of the chemical-specific ARARs for the MTL site (see Table 4-1) is discussed below.



4.1.1.1 RCRA Requirements (40 CFR 261-268) and Massachusetts Hazardous Waste Management Rules (310 CMR 30)

RCRA requirements become applicable to the MTL site when chemically contaminated materials found at the site are remediated. The waste materials generated as a result of remediation could be classified as RCRA hazardous wastes (either listed or characteristic hazardous waste). In particular, beryllium dust is a listed RCRA hazardous waste (hazardous waste P-015, as per 40 CFR 261.33).

Regulations promulgated under this act define hazardous wastes and generally establish technology-based requirements for active or proposed hazardous waste facilities. RCRA requirements include, for example, groundwater protection, closure, and minimum technology requirements for hazardous waste treatment, storage, and disposal (TSD) facilities. In the case of the MTL site, RCRA applies to disposal of hazardous waste during remediation.

The Massachusetts Hazardous Waste Management Rules (310 Code of Massachusetts Regulations [CMR] 30) are virtually equivalent to the RCRA regulations. The notable exception is that oil is classified as a hazardous substance in Massachusetts, with waste oil constituting a hazardous waste. In addition, waste oil residues contaminated with radioactivity are classified by MADEP as low-level wastes only and not mixed wastes.

4.1.1.2 Federal Safe Drinking Water Act (SDWA)

The SDWA mandated EPA to establish regulations to protect public health from contaminants in drinking water. These contaminants include various VOCs, pesticides, metals, PAHs, nitrates, asbestos, cyanide, and radiological constituents. The Charles River and groundwater in the vicinity of the MTL site are not used as drinking water sources. Instead, drinking water is obtained from the Quabbin Reservoir. Consequently, the SDWA may not be directly applicable, although it may be considered relevant or appropriate (to prevent the degradation of water resources).

EPA has developed two sets of drinking water standards, referred to as primary and secondary standards, to protect public health and to ensure the aesthetic quality of drinking water, respectively. The secondary standards are not enforceable at the federal level.

National Interim Primary Drinking Water Standards instituted under the SDWA are promulgated (in 40 CFR 141 through 143) as maximum contaminant levels (MCLs), which represent the maximum allowable levels of selected constituents in public water systems.

Maximum contaminant-level goals (MCLGs) are unenforceable, health-based concentrations at which no known or anticipated adverse effects will occur with an adequate margin of safety. MCLs are set as close as feasible to MCLGs, while taking into account available treatment technologies and costs. While MCLs are usually adopted as ARARs, a standard for drinking water more stringent than an MCL may be



required under special circumstances, such as when multiple contaminants in groundwater or multiple pathways of exposure present extraordinary risks.

Table 4-2 presents MCLs and MCLGs (where available). MCLs are established for drinking water and should not be used as standards for groundwater quality where interception, natural attenuation, or appropriate treatment are employed prior to use as potable water.

4.1.1.3 Federal Water Quality Criteria

The provisions of CERCLA Section 121 state that remedial actions shall attain federal water quality criteria where they are relevant and appropriate. Federal water quality criteria documents have been published for 65 pollutants listed as toxic under the Clean Water Act (CWA). Some of these criteria are unenforceable guidelines, or TBCs, that may be used by states to set surface water quality standards. Although these criteria were intended to represent a reasonable estimate of pollutant concentrations consistent with the maintenance of designated water uses, states may appropriately modify these values to reflect local conditions.

The water quality criteria are generally represented in categories that are aligned with different surface water use designations. Concentrations are specified that should, if not exceeded, protect most aquatic life against acute toxicity or chronic toxicity (24-hour average). For many chemical compounds, specific criteria have not been established because of insufficient data. Table 4-2 provides the most recent water quality criteria. Water quality criteria for the protection of aquatic life and the protection of human health (fish consumption) are presented (i.e., consistent with the uses of the Charles River). For the parameters for which state standards have been established, the more stringent standard may be considered the appropriate ARAR.

4.1.1.4 State Surface Water Quality Standards

The Massachusetts Surface Water Quality Standards (314 CMR 4.0) are considered to be ARARs for Charles River water quality.

4.1.1.5 State Groundwater Quality Standards

The Massachusetts Contingency Plan (MCP) Method 1 Groundwater Standards (314 CMR 40.0) and the Massachusetts Groundwater Quality Standards (314 CMR 6.0) are considered to be ARARs for discussing groundwater contamination. The MCP regulations became final in October 1993. These standards are presented in Table 4-2. Discussions with the state indicated that neither standard currently supersedes the other.

As part of the MCP Method 1 Groundwater Standards, several categories of state groundwater standards have been developed based on the foreseeable use of the groundwater. Categories are as follows:



- GW-1: Groundwater in areas that are likely to contribute, or could potentially contribute, to a groundwater supply is held to the most stringent standards. Based on a definition of GW-1, as presented in 310 CMR 40.0932 (4 and 5), no water beneath the MTL site was classified as GW-1.
- GW-2: Groundwater considered to be a potential source of toxic vapors to indoor air. Based on the definition of GW-2, as presented in 310 CMR 40.0932 (6), all shallow groundwater (i.e., all groundwater collected from shallow wells beneath the MTL site) was assumed to be GW-2.
- GW-3: All groundwater that could potentially serve as a source of discharge to surface water. As discussed in 310 DMR 40.0932 (3), all groundwater will, at a minimum, be considered GW-3. In general, the GW-3 category is held to the least stringent groundwater standards. All deep groundwater (i.e., all water collected from deep monitor wells beneath the MTL site) was classified as GW-3.

In Section 4, comparison of groundwater data to MCP Method 1 Groundwater Standards is for discussion purposes only. The comparison does not determine whether remedial action is required. The MCP Method 1 Groundwater Standards are superseded when a multimedia risk assessment is performed. A multimedia risk assessment has been completed for the MTL site.

4.1.1.6 Federal Draft National Sediment Quality Criteria

The Federal Draft National Sediment Quality Criteria are considered to be ARARs for Charles River sediment quality. The sediment quality criteria are currently in draft form. Presently, only five compounds (acenaphthene, fluoranthene, phenanthrene, dieldrin, and endrin) have sediment quality criteria values.

4.1.1.7 State Soil Standards

The MCP Method 1 Soil Standards (314 CMR 40.0) are considered to be ARARs for discussing soil contamination. These regulations became final in October 1993. As set forth in the MCP guidelines, soils are categorized into one of three categories for comparison. The soils are categorized based on receptor characteristics and accessibility of the soil to potential receptors. The soil standards used for comparison also depend on the category of groundwater in the associated area. These standards are presented in Tables 4-9 through 4-11.

In Section 4, comparison of soil data to MCP Method 1 Soil Standards is for discussion purposes only. The comparison does not determine whether remedial action is required. The MCP Method 1 Soil Standards are superseded when a multi-media risk assessment is performed. A multimedia risk assessment has been completed for the MTL site.



4.1.1.8 NRC and State Standards for Protection Against Radiation

NRC Standards (10 CFR 20) and Massachusetts DPH Standards (105 CMR 120) are considered to be ARARs for materials emitting radiation. These standards are presented in Tables 4-3 and 4-4, respectively. Radiological cleanup standards are also presented in Tables 4-3 and 4-4. These standards are based on radiological dose assessments of exposure to radionuclides on building surfaces and in the soil and water. These standards are appropriate to use instead of values derived from an RA because they are standards that have been promulgated by regulatory agencies based on their assessment of health risks from radiological exposure.

4.1.1.9 State and National Air Quality Standards

The Massachusetts Ambient Air Quality Standards (310 CMR 6.0) and the National Ambient Air Quality Standards (NAAQS) (40 CFR 50) may be applicable if the site has the potential for airborne discharges. Of the compounds identified at the site, these standards apply to two. The standard for lead is $1.5 \,\mu\text{g/m}^3$ within a calendar quarter. The standard for particulates (particle mass <10 microns, i.e., PM-10) is $50 \,\mu\text{g/m}^3$ within a calendar year and $150 \,\mu\text{g/m}^3$ within a 24-hour period.

Other potential ARARs include occupational exposure standards and guidelines for airborne contaminants. Enforceable regulatory standards include the Permissible Exposure Levels (PELs) from the Occupational Safety and Health Administration (OSHA). Known PELs are listed in Table 4-5. In addition to the enforceable PELs, recommended occupational exposure guidelines are also relevant and appropriate. These guidelines include the Threshold Limit Values (TLVs) from the American Conference of Governmental Industrial Hygienists (ACGIH) and the Recommended Exposure Levels (RELs) from NIOSH. These guidelines are also listed in Table 4-5.

It is important to distinguish the significant differences between establishing exposure levels for the general public and using the occupational exposure standards and guidelines. Current public health standards/guidelines, including those from EPA (NAAQS), the World Health Organization (WHO), and the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE), are generally one to two orders of magnitude lower (more protective) than the occupational exposure standards for short- and long-term exposure limits. Several factors account for these variations:

- Occupational standards do not include protection for the old, young, pregnant women, those with preexisting respiratory ailments, and other sensitive individuals in the population; they typically presume a healthy adult workforce and may explicitly accept that a very small percentage of the workforce will experience adverse health effects at the occupational exposure limits.
- Occupational exposure limits assume exposure periods of no more than 8 hours per day, 40 hours per week.



- Occupational limits are established in consideration of the technical and economic feasibility of their implementation; they are not based solely on established health criteria.
- Implicit in occupational standards is the assumption that exposure is voluntary (inherent in the chosen occupation).

Known WHO and ASHRAE guidelines are also listed in Table 4-5, and are considered to be relevant and appropriate. There are fewer contaminants covered under WHO and ASHRAE guidelines than under the occupational health guidelines.

4.1.2 TBCs FOR THE MTL SITE

TBCs are nonpromulgated, unenforceable advisories or guidance, issued by the federal or state government, that is not legally binding and does not have the status of potential ARARs; however, TBCs should be considered along with ARARs. TBCs can include health advisories, RfDs and potency factors, proposed rules, guidance materials, or policy documents. Evaluating TBCs requires professional judgment based on the latest available information.

Standards for residual surface contamination generally are not available but would be helpful in evaluating the need for remedial action at the MTL site. A method developed by the State of New Jersey, based on the potential for risk to human health, was used to calculate guidelines for allowable residual surface contamination at the MTL site. Neither EPA nor MADEP has promulgated similar guidelines or protocols. The calculations incorporate an initial assumption of a 10^{-6} human health risk factor. The calculations were conducted as part of the RA and are discussed further in Section 6; however, it should be noted here that for contaminants for which an oral RfD exists, the standards for residual surface contamination were calculated based on that RfD. In instances where no oral RfD was available, the equation used was based on the contaminant potency factor (PF). In both instances, a human health risk of 10^{-6} is assumed.

For lead, however, the standard is based upon the September 1990 HUD clearance criteria for lead abatement projects, which is the most recent published regulatory guidance on building interior concentrations (New Jersey Department of Environmental Protection and Energy [NJDEPE], January 1992).

Additionally, for PCBs, arsenic, antimony, cadmium, and mercury, published NJDEPE guidelines (January 1992) were used rather than calculated levels. The calculated guidelines for contaminants identified at the MTL site are listed in Table 4-6 (see Appendix J for further information).



4.2 GEOPHYSICAL RESULTS

The following subsections discuss the results of the geophysical survey conducted at MTL. More than 600 ft of hard-copy GPR profiles were examined and interpreted. These profiles are stored in WESTON's West Chester, Pennsylvania, offices.

Interpretation of GPR profiles revealed four different types of GPR signatures:

- Undisturbed zones
- Point source reflectors
- Areas with multiple point source reflectors
- Areas with dipping reflectors

Each of these signatures is discussed briefly below and depicted on one of two representative GPR profiles (Figures 4-1 and 4-2). The GPR profiles are displayed with both pulse time and depth as the vertical axis. The horizontal axis of the profile measures traverse distance in feet. The dashed vertical lines represent the positions of grid nodes.

In reviewing these profiles, it should be noted that there is significant vertical exaggeration. On the horizontal axis, 1 inch is equal to approximately 11.3 ft, whereas 1 inch on the vertical axis is equal to approximately 2.16 ft. This results in a vertical exaggeration of approximately 5:1. Therefore, the slope of a reflector will appear steeper than it actually is.

Undisturbed zones are characterized by relatively flat bands of reflectors appearing in the upper part of a GPR profile. In Figure 4-1, these reflectors appear in the upper 40 ns of the profile, corresponding to a depth of approximately 6.3 ft. These zones may represent areas where earth materials are undisturbed or where local sands and silt were used as fill.

A point source reflector is characterized by a distinctive hyperbolic shape (i.e., an upside-down "U") on the radar profile. In some cases, the radar signal will reverberate or be repeated many times below the initial occurrence of the point source reflector. This occurs when a portion of the radar signal returning to the surface is reverberated between more shallow interfaces (i.e., soil horizons or the soil/air interface). An example of a point source reflector is found at 100 south on Figure 4-1. Point source reflector signatures are generated by reflections from isolated buried objects.

A dense concentration of point source reflectors creates the signature of a multiple point source reflector. The hyperbolic shape is not as distinct. In many cases, these signatures are observed and are associated with features interpreted as fill zones and, therefore, are zones of deeper radar penetration. Figure 4-2 shows an example of multiple point source reflectors. Multiple point source reflectors are thought to result from clusters of rocks or relatively dense concentrations of debris.



Dipping reflectors, as the name implies, are GPR reflectors that dip at various angles on the profiles. An example is shown in Figure 4-2. Note that because of vertical exaggeration, the slope of a reflector will appear steeper than it actually is. Dipping reflectors are interpreted as dipping soil horizons.

4.2.1 IDENTIFICATION OF USTs

Two disturbed areas were found in the parking lot between Buildings 37 and 131. These areas are shown in Figure 4-3, which also shows a series of discrete buried objects that are believed to coincide with a 12-inch sewer line. One area, located between the fourth and seventh parking spaces in the northern half of the lot, also had elevated conductivity readings, perhaps indicating buried metal. This area is the possible location of a former UST. Aerial photographs from the years between 1938 and 1962 indicate the presence of a grassy island (grass does not appear in later photographs) containing what appears to be a gasoline or diesel fuel pump south of Building 37 and east of (former) Building 921. This is especially evident in a March 1949 aerial photograph of the site. Additionally, a photograph taken from the ground in the 1940s clearly shows the fuel pump in the location indicated by aerial photos. The geophysical results indicate the presence of buried metal approximately 100 ft northeast of the pump island. It is possible that the supply tank for the fuel pump was located in this area. Both Phase 1 and Phase 2 results indicated the presence of fuelrelated compounds in well C-2, located just downgradient of the fuel pump location, and approximately 100 ft from the suspected UST location (see Subsection 4.4.3). These results support the existence of a UST in this area; however, the limitations of geophysical methods necessitate further investigation of the area using subsurface investigations to make an exact determination as to the presence of a UST in this area.

4.2.2 FILL AREAS

Three areas were surveyed for the presence of fill. These areas include the park on the Charles River, the on-site area north of North Beacon Street, and the areas south and west of Building 60.

Most of the western half of the park was characterized by GPR signatures that typify multiple reflectors (Figure 4-4). The northwestern corner of this area also had high conductivity readings, suggesting that there is a potential for buried metal in this area. Other fill areas included the area within 50 ft of the sidewalk along North Beacon Street, the southeastern corner of the grassy area, and two small areas about 150 ft south of the street. Two of these areas also had high conductivity readings, suggesting the potential of buried metal: one small area near 150 south, 340 west; and the northeast corner of the park. Also identified were 55 signatures of isolated buried objects. In general, the eastern half of the park appeared undisturbed on the radar profiles, and a strong reflection, at an average depth of 6 to 7 ft, was seen. This reflection was probably associated with the firm, saturated, high-plasticity silt and clay described on the soil boring logs. This layer may represent the former river bottom, since it appeared to slope upwards towards the north. If this area received fill materials, local sands and silts with little to no debris were probably used.



In the area north of North Beacon Street, 23 areas with GPR signatures characteristic of areas with multiple reflectors were found, as depicted on Figure 4-4. This area was wooded, so some of the multiple reflectors may be tree roots rather than debris. Also identified were 19 isolated objects. The EM-31 was not very effective in this area because of the iron fence and utilities along the street, but three areas with high conductivity readings were identified, one near the propellant storage area and two near the steep bank to the north, one near 625 west and one at 450 west.

Three disturbed areas with GPR signatures characteristic of multiple reflectors were located near Building 60. These areas are shown on Figure 4-5. The hillside and flat area southwest of the building appear to be all fill. This is confirmed by the presence of slag on the hillside. No EM-31 measurements were taken here because there were too many buried utilities for readings to be meaningful.

4.2.3 STORM/SANITARY SEWER LINES

Five sewer junctions were examined. The results are presented on Figures 4-6A through 4-6D and are discussed below.

The site storm drainage map was found to be correct for junction 9SLG01 near the front gate. The observed configuration of this junction is shown in Figure 4-6A. ADL apparently mistook crumbling brickwork for an inlet pipe.

At location 17AQU01, the ADL diagram did not indicate the outfall to the river (Figure 4-6B). The junction is also not correct as previously diagrammed. There are two inflow pipes from the northeast and none from the southeast.

WESTON concurs with the ADL diagram for 17AQU02. One outfall was observed, although the storm drainage map shows two. It is possible, however, that a second outfall pipe may have been located beneath the water surface at a depth of more than 15 ft bgs. Because the depth was too great, this apparent discrepancy could not be resolved using geophysics.

The pipe configuration at junction 16AQU01 differs from both the ADL report and the storm drainage map and is depicted on Figure 4-6C. ADL's diagram did not indicate the outfall to the Charles River. There is one additional pipe entering from the southwest that is not indicated on the storm drainage map. The two pipes from the southwest appear to come from a grated manhole and a storm drain crossing the driveway.

GPR and visual observation were used to resolve the discrepancies at junction 18AQU03. The observed configuration is shown in Figure 4-6D. The ADL diagram did not indicate the outfall to the Charles River. The actual configuration of the pipes differs from both ADL's sketch and the site drainage map. Five pipes drain into this junction, but only three of these are shown on the site map. The 8-inch and 4-inch pipes do not appear on the drainage map. GPR was used to confirm that the 8-inch



pipe did not bend within 50 ft of the junction, but the 4-inch pipe was too small to be seen at a 7-ft depth with GPR.

4.3 SOIL SAMPLING RESULTS

Between 7 October and 14 November 1992, WESTON collected 176 soil samples (excluding duplicates, field blanks, and trip blanks) for laboratory analysis. All soil samples submitted to the laboratory were analyzed for the following parameters: TCL organics; cyanide; TAL metals; and radioactive parameters, including gross alpha and beta activity, U-234, U-235, and U-238. In addition, selected soil samples were analyzed for TOC, cesium-137, and thorium-230.

A combination of surface and boring samples was collected for laboratory analysis and used to evaluate contaminant distribution around the MTL facility. Surface soil samples were collected with stainless steel scoops and bowls at depths ranging from 0 to 0.5 ft bgs. A total of 30 surface soil samples collected by these hand methods were submitted for laboratory analysis. Surface sampling locations are identified in Figure 4-7. Boring samples were collected using hollow-stem soil augers and split spoon samplers at sampling depths ranging from ground surface to 36 ft bgs. A total of 146 boring samples, collected from 62 boring locations, were submitted for laboratory analysis during Phase 2. Boring locations are identified in Figure 4-8.

To aid with WESTON's assessment of soil analytical results, soil sampling locations were divided among 18 management units previously delineated in a preliminary site investigation. Management unit boundaries are shown in Figure 1-3. Management units were developed during Phase 1 as a way of separating various potential contamination sources into separate zones and providing a systematic approach for review of analytical results.

The primary method of assessing soil analytical results was to compare the chemical results to the MCP Method 1 Soil Standards. As set forth in the MCP guidelines, soils are categorized into one of three categories for comparison. The soils are categorized based on receptor characteristics and accessibility of the soil to potential receptors, and the category of groundwater in the associated area. Table 4-7 lists the category for each soil sample, organized by management unit. The soils were categorized using the following criteria:

- The soils were categorized into one of four preferred major use zones as shown based on Figure 6-2.
- All samples at a depth greater than 15 ft bgs were categorized as S-3.
- All of Zone 4 was categorized as S-1 except for samples collected at depths greater than 15 ft bgs.



• Zones 1, 2, and 3 were categorized as S-1, except for paved areas or unpaved areas at a depth greater than 3 ft bgs, which were categorized as S-2.

The category of groundwater used for the soil comparison was GW-2 (see Subsection 4.1.1.5.). The proposed MCP Method 1 Soil Standards are presented in Tables 4-8 through 4-10.

4.3.1 UPGRADIENT BORINGS

Upgradient borings were installed to establish background conditions in areas located outside the influence of activities at MTL. Seven soil borings were used to collect background soil data. Four of these soil borings, BKSB1 through BKSB4, were constructed at off-site locations just north of Arsenal Street. These locations are upgradient of the facility, based on surface topography, which would indicate that any potential discharges from MTL would not be directed towards these borings. Each boring was located in an area that was not affected by current or past industrial activities at the facility and reflected the typical conditions of the area. Three soil borings used as background locations were installed on the MTL property. These borings were placed in a northwestern portion of the facility, based on the surface topography, in locations upgradient of areas where hazardous constituents were managed (01SB-3, GRSB-1, and GRSB-4). These locations were carefully selected, based on past historical use of the property, in an area that was not believed to have ever been used for waste management, based on historical records review. These sample points were also located in such a way that surface soils from facility areas where waste may have been managed could not have been directed to these sampling locations. Three surface soil samples, 01SS-1, 02SS-1, and 03SS-3, were used to supplement surface background data analysis. 01SS-1 and 02SS-1 were also collected in a northwest portion of the facility at locations upgradient of industrial activities at the MTL facility. This location was also upgradient of all industrial activities at MTL and appears to be located in an area that was not affected by past historical uses of this area.

Phase 2 work involved analysis of three surface soil samples (01SS-1, 02SS-1, and 03SS-3) and 23 boring samples collected from seven soil borings (01SB-3, BKSB-1, BKSB-2, BKSB-3, BKSB-4, GRSB-2, and GRSB-3). Sampling depths ranged from ground surface to 22 ft bgs. Table 4-11 lists background soil concentrations for detected parameters.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in upgradient samples (all sample depths are 0 ft bgs unless noted):

PAHs

- Benzo[a]anthracene in BKSB-1, BKSB-3, 01SS-1, 02SS-1, and 03SS-3.
- Benzo[a]pyrene in BKSB-3, 01SS-1, and 02SS-1.



- Benzo[b]fluoranthene and benzo[k]fluoranthene in BKSB-1, BKSB-3, 01SS-1, 02SS-1, and 03SS-3.
- Chrysene in BKSB-1, BKSB-3, 01SS-1, and 02SS-1.
- Dibenz[a,h]anthracene in 02SS-1.
- Indeno[1,2,3-c,d]pyrene in BKSB-3, 01SS-1, and 02SS-1.

Anthracene was detected in BKSB-3 at greater than 6.2 μ g/g. The MCP standard is 1,000 μ g/g.

Fluoranthene and pyrene were detected in 02SS-1 at greater than 6.2 μ g/g. The MCP standards for fluoranthene and pyrene are 900 μ g/g and 700 μ g/g, respectively.

Pesticides

- Chlordane in 02SS-1 and 03SS-3.
- Dieldrin in BKSB-3 and 02SS-1.

These results for organic compounds indicate that the soil around MTL contains a significant number of organic compounds possibly from years of industrial, commercial, and transportation activities in the Watertown area.

Metals

- Arsenic in BKSB-3 and 03SS-3.
- Beryllium in 01SB-3 at 2, 4, 6, 8, 12 and 14 ft bgs; in BKSB-2 at 14 ft bgs; in BKSB-3 at 4 and 14 ft bgs; in BKSB-4 and GRSB-3 at 0 and 12 ft bgs; and in 02SS-1 (14 of 26).
- Lead in 01SS-1, 02SS-1, and 03SS-3.

The presence of these and other metals is most likely the result of a combination of natural levels and industrial, commercial, and transportation activities in the Watertown area.

4.3.2 UNIT 1

Management Unit 1 is located in the northwest corner of the MTL site and includes Buildings 243 and 246, a paved parking lot west of Building 311, and a small grassy area.

Phase 2 work involved collecting six boring samples from three soil borings (01SB-1, 01SB-2, and GRSB-1) at depths ranging from 0 to 19 ft bgs (01SB-3 was collected from an upgradient portion of the management unit and was treated as a background



sample). Laboratory analytical results for detected parameters are presented in Table 4-13.

Only three chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 1 (all samples are from the surface unless noted):

- Benzo[b]fluoranthene in GRSB-1.
- Benzo[k]fluoranthene in 01SB-1.
- Beryllium in 01SB-1, 01SB-2 at 8 ft bgs, and GRSB-1.

All chemical concentrations were below the maximum concentrations detected in upgradient samples.

4.3.3 UNIT 2

Management Unit 2 includes Building 311 and a paved area east of the building.

Phase 2 work involved collecting two surface samples (02SS-2 and 02SS-3) and six boring samples. The boring samples were collected from three soil borings (02SB-2, 02SB-3, and 02SB-4). Sampling depths ranged from ground surface to 16 ft bgs. Laboratory analytical results are presented in Table 4-13.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 2 samples:

PAHs

- Benzo[b]fluoranthene in 02SB-3 at 1 ft bgs and GRSB-2 at 0 ft bgs.
- Benzo[k]fluoranthene in 02SB-3 at 1 ft bgs.
- Chrysene and indeno [1,2,3-c,d] pyrene in GRSB-2.

Pesticides and PCBs

Dieldrin and PCB 1260 in 02SS-3.

Metals

- Beryllium in 02SB-2 and 02SB-3, both at 1 and 14 ft bgs.
- Lead in 02SS-2.

Bis(2-ethylhexyl)phthalate was detected at a concentration greater than 6.2 μ g/g in 02SB-2 at 1 ft bgs. The MCP standard for bis(2-ethylhexyl)phthalate is 300 μ g/g.



4.3.4 UNIT 3

Management Unit 3 is located in the northeast corner of the site and consists of Building 43, a guard shack at the main entrance to the facility, and small grassy and paved areas between the guard shack and Building 43.

Phase 2 work involved collecting two surface samples (03SS-1 and 03SS-2) and three boring samples. The boring samples were collected from two soil borings (03SB-1 and 03SB-2). Sampling depths ranged from ground surface to 22 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-14.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 3 samples:

Volatiles

Methylene chloride was detected at a concentration greater than 10 μ g/g in 03SB-2 at 0 ft bgs. The MCP standard for methylene chloride is 200 μ g/g.

Metals

- Beryllium in 03SS-1.
- Lead in 03SS-1 and 03SS-2.
- Nickel in 03SB-2 at 0 ft bgs.

4.3.5 UNIT 4

Management Unit 4 is located in the west end of the site, immediately south of Unit 1. The unit consists of a large parking lot and is almost entirely covered with asphalt, except for small grassy areas at the boundaries of the parking lot. The unit also includes a guard shack situated next to the rear entrance to the facility.

Phase 2 work involved collecting one surface soil sample (04SS-1) and one boring sample (04SB-1). Sampling depths ranged from ground surface to 0.5 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-15.

The only chemical exceeding the MCP Method 1 Soil Standards in Unit 4 was beryllium in 04SB-1 at 0 ft bgs and in 04SS-1. Both concentrations were below the maximum exceedances detected in upgradient samples.

4.3.6 UNIT 5

Management Unit 5 is located immediately east of Unit 4 and includes Laboratory Building 39, two small storage buildings (229 and 656), and an asphalt parking lot.

Phase 2 work involved collecting two surface samples (05SS-1 and 05SS-2) and four boring samples. The boring samples were collected from three soil borings (05SB-1, 05SB-2, and GRSB-5). Sampling depths ranged from ground surface to 30 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-16.



The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 5 samples:

Volatiles

• 1,1,2,2-Tetrachloroethane in 05SB-1 at 30 ft bgs.

PAHs

- Benzo[a]anthracene, benzo[k]pyrene, and benzo[k]fluoranthene in 05SS-1 and 05SS-2.
- Benzo[b]fluoranthene in GRSB-5 at 0 ft bgs, 05SS-1, and 05SS-2.
- Chrysene in 05SS-2.
- Dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene in 05SS-1.

Fluoranthene and pyrene were detected at concentrations greater than 6.2 μ g/g in 05SS-1. The MCP standards for fluoranthene and pyrene are 900 μ g/g and 700 μ g/g, respectively.

Pesticides

Chlordane in 05SS-1 and 05SS-2.

Surface pesticides may be attributed to regular application for pest control.

Metals

- Beryllium in 05SB-1 at 0 ft bgs, 05SB-2 at 0 and 10 ft bgs, and GRSB-5 at 12 ft bgs.
- Lead in 05SB-2 at 0 ft bgs.

4.3.7 UNIT 6

Management Unit 6 is located in the central portion of the site and consists of Buildings 97, 100 (reactor building), and 292. The remainder of the unit consists primarily of lawn.

Phase 2 work involved collecting four shallow soil samples (06SS-1, 06SS-2, 06SS-3, and 06SS-4) and 13 boring samples. The boring samples were collected from six soil borings (GRSB-6, 06SB-1, 06SB-2, 06SB-3, 06SB-4, and 06SB-5). Sampling depths ranged from ground surface to 25 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-17.



The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 6 samples (all sample depths are 0 ft bgs unless noted):

PAHs

- Benzo[a]anthracene in 06SB-1, 06SB-2, 06SB-4, 06SB-5, and GRSB-6.
- Benzo[a]pyrene and benzo[k]fluoranthene in 06SB-1, 06SB-5, and GRSB-6.
- Benzo[b]fluoranthene in 06SB-1, 06SB-2, 06SB-5, and GRSB-6.
- Chrysene in 06SB-1, 06SB-2, 06SB-4, and GRSB-6.
- Dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene in 06SB-1 and 06SB-5.

Fluoranthene was detected in 06SB-1 at greater than 6.2 μ g/g. The MCP standard is 900 μ g/g.

Pyrene was detected in 06SB-1 and GRSB-6, both at greater than 6.2 μ g/g. The MCP standard is 700 μ g/g.

Pesticides

- Chlordane in 06SS-4.
- Dieldrin in 06SB-1, 06SB-5, GRSB-6, and 06SS-4.
- Heptachlor epoxide in GRSB-6 and 06SS-4.
- DDT in GRSB-6.

Surface pesticides may be attributed to regular application for pest control.

Metals

- Beryllium in 06SB-1, 06SB-2, 06SB-3 at 4 ft bgs, 06SB-4, 06SB-5, GRSB-6, 06SS-3, and 06SS-4.
- Lead in 06SS-4.

4.3.8 UNIT 7

Management Unit 7 is located in the central portion of the site and consists of Building 36 and paved areas surrounding the building.

Phase 2 work involved collecting six boring samples from three soil borings (07SB-1, GRSB-7, and GRSB-8) at depths ranging from ground surface to 14 ft bgs. No surface samples were collected. Laboratory analytical results for detected parameters are presented in Table 4-18.



The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 7 samples (all sample depths are 0 ft bgs unless noted):

Volatiles

• 1,1,2,2-Tetrachloroethane in 07SB-1.

1,1,2,2-Tetrachloroethane was not detected in the same boring at 14 ft bgs.

PAHs

• Benzo[a]anthracene, benzo[b]fluoranthene, and benzo[k]fluoranthene in 07SB-1.

Pesticides

• Dieldrin in 07SB-1.

Metals

 Beryllium in 07SB-1 at 0 and 14 ft bgs, GRSB-7 at 14 ft bgs, and GRSB-8 at 0 and 14 ft bgs.

All concentrations were below the maximum exceedance in upgradient samples.

4.3.9 UNIT 8

Management Unit 8 consists of Building 312 and an area of asphalt and lawn that surrounds the building.

Phase 2 sampling consisted of collecting and analyzing one surface sample (08SS-1) and five boring samples. The boring samples were collected from two soil borings (08SB-2 and 08SB-3). Sampling depths ranged from 0.2 ft bgs to 10 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-19. The subsurface borings were completed inside Building 312. Original plans called for completing a third boring (08SB-1) inside Building 312; however, the boring was not completed because of overhead clearance limitations inside the building.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 8 samples:

PAHs

• 2-Methylnaphthalene in 08SB-2 at 1 ft bgs.



- Benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, and indeno[1,2,3-c,d]pyrene in 08SB-2 at 1 and 4 ft bgs and 08SB-3 at 1 ft bgs.
- Chrysene in 08SB-2 at 1 and 4 ft bgs and 08SB-3 at 1 and 10 ft bgs.
- Dibenz[a,h]anthracene in 08SB-2 at 1 and 4 ft bgs.

Anthracene was detected at greater than 124 μ g/g in 08SB-2 at 1 ft bgs. The MCP standard for anthracene is 2,500 μ g/g.

Fluoranthene was detected at greater than 124 μ g/g in 08SB-2 at 1 ft bgs; at greater than 6.2 μ g/g in 08SB-2 at 4 ft bgs; and at greater than 6.2 μ g/g in 08SB-3 at 1 ft bgs. The MCP standard for fluoranthene is 2,000 μ g/g.

Phenanthrene was detected at greater than 240 μ g/g in 08SB-2 at 1 ft bgs; at greater than 12 μ g/g in 08SB-2 at 4 ft bgs; and at greater than 12 μ g/g in 08SB-3 at 1 ft bgs. The MCP standard for phenanthrene is 2,500 μ g/g.

Pyrene was detected at greater than 124 μ g/g in 08SB-2 at 1 ft bgs; at greater than 6.2 μ g/g in 08SB-2 at 4 ft bgs; and at greater than 6.2 μ g/g in 08SB-3 at 1 ft bgs. The MCP standard for pyrene is 2,000 μ g/g.

Borings 08SB-2 and 08SB-3 were completed underneath Building 312. The detected PAH compounds could be attributed to the fill used underneath the building's foundation, such as coal ash.

Pesticides

- Aldrin in 08SB-2 at 1 ft bgs.
- Dieldrin in 08SB-2 and 08SB-3, both at 1 ft bgs.

Metals

Beryllium in 08SB-2 at 1 and 4 ft bgs and 08SB-3 at 6 and 10 ft bgs.

4.3.10 UNIT 9

Management Unit 9 consists of Building 313 and a small area of asphalt and lawn that surrounds the building.

Phase 2 sampling consisted of collecting and analyzing two surface samples (09SS-1 and 09SS-2) and seven boring samples. The boring samples were collected from three soil borings (09SB-1, GRSB-9, and GRSB-10) at sampling depths ranging from ground surface to 34 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-20.



The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 9 samples (all sample depths are 0 ft bgs unless noted):

PAHs

- Benzo[a]anthracene, benzo[k]fluoranthene, and chrysene in GRSB-9 and GRSB-10.
- Benzo[a]pyrene and indeno[1,2,3-c,d]pyrene in GRSB-9.
- Benzo[b]fluoranthene in 09SB-1, GRSB-9, and GRSB-10.

Pyrene was detected in GRSB-9 at greater than 6.2 μ g/g. The MCP limit is 700 μ g/g.

Detected PAH compounds could be attributed to the fill used underneath the building.

Pesticides

- Aldrin, dieldrin, and heptachlor epoxide in 09SS-1.
- Chlordane in 09SB-1.

Metals

- Beryllium in 09SB-1 at 0 and 2 ft bgs, GRSB-9, GRSB-10, and 09SS-2.
- Nickel in 09SS-2.
- Lead in 09SS-1 and 09SS-2.

Mercury was detected in 09SS-2 at greater than 1 μ g/g. The MCP limit is 10 μ g/g.

4.3.11 UNIT 10

Management Unit 10 is located in the central portion of the site and consists primarily of an asphalt parking lot south of Building 36.

Phase 2 sampling consisted of collecting and analyzing five boring samples from two soil borings (10SB-1 and 10SB-2) at sampling depths ranging from 0.2 ft to 26 ft bgs. No surface samples were collected. Laboratory analytical results for detected parameters are presented in Table 4-21.

Benzo[b]fluoranthene and benzo[k]fluoranthene, in 10SB-1 at 0 ft bgs, were the only chemicals exceeding the MCP Method 1 Soil Standards in Unit 10.

4.3.12 UNIT 11

Management Unit 11 consists of Building 37 and a parking lot south of the building.



Phase 2 sampling consisted of collecting and analyzing 14 boring samples from five soil borings (11SB-1, 11SB-2, 11SB-3, 11SB-4, and GRSB-15). Sampling depths ranged from ground surface to 34 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-22.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 11 samples (all sample depths are 0 ft bgs unless noted):

PAHs

- Benzo[a]anthracene, benzo[a]pyrene, benzo[k]fluoranthene, and chrysene in 11SB-4 and GRSB-15.
- Benzo[b]fluoranthene in 11SB-2, 11SB-4, and GRSB-15.
- Dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene in GRSB-15.

Fluoranthene and pyrene were detected at concentrations greater than 6.2 μ g/g in GRSB-15. The MCP standards for fluoranthene and pyrene are 900 and 700 μ g/g, respectively.

Detected parameters may be attributed to the fill used for the parking lot.

Explosives

• 2,6-Dinitrotoluene in 11SB-4.

Pesticides

- Chlordane in GRSB-15.
- Dieldrin in 11SB-4 and GRSB-15.

Metals

- Arsenic in GRSB-15.
- Beryllium in 11SB-4 and GRSB-15.
- Lead in 11SB-2.

Mercury was detected in 11SB-4 at greater than 1 μ g/g. The MCP limit is 10 μ g/g.

4.3.13 UNIT 12

Management Unit 12 consists of the steam generation plant (Building 60) and an asphalt-paved area surrounding it.

Phase 2 sampling consisted of collecting and analyzing 14 boring samples from five soil borings (GRSB-12, GRSB-13, 12SB-1, 12SB-2, and 12SB-3) at depths ranging from



ground surface to 28 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-23.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 12 samples:

PAHs

- Benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, and chrysene in 12SB-2 at 4 and 8 ft bgs and 12SB-3 at 0 ft bgs.
- Benzo[a]pyrene, dibenz[a,h]anthracene, and indeno[1,2,3-c,d]pyrene in 12SB-2 at 8 ft bgs.

Fluoranthene was detected at greater than 6.2 μ g/g in 12SB-2 at 8 ft bgs. The MCP limit is 2,000 μ g/g.

Phenanthrene was detected at greater than 12 μ g/g in 12SB-2 at 8 ft bgs. The MCP limit is 2,500 μ g/g.

Pyrene was detected at greater than 6.2 μ g/g in 12SB-2 at 8 ft bgs. The MCP limit is 2,000 μ g/g.

Parameters detected in 12SB-2 could be attributed to fill used around Building 60, as Figure 4-5 indicates.

Pesticides

Dieldrin in 12SB-1 at 0.5 ft bgs and 12SB-2 at 4 ft bgs.

Metals

- Beryllium in GRSB-12 at 0 ft bgs.
- Lead in 12SB-2 at 4 ft bgs.

4.3.14 UNIT 13

Management Unit 13 is located in the southeastern portion of the site and contains residential buildings, an administrative building (Building 131), and a large grassy area.

Phase 2 sampling consisted of collecting 7 surface samples (13SS-1, 13SS-2, 13SS-3, 13SS-5, 13SS-6, 13SS-7, and 13SS-8) and 12 boring samples. The boring samples were collected from five soil borings (GRSB-17, GRSB-21, 13SB-1, 13SB-2, and 13SB-3). Sampling depths ranged from ground surface to 32 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-24.



The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 13 samples (all sample depths are 0 ft bgs unless noted):

PAHs

- Benzo[a]anthracene and benzo[a]pyrene in 13SS-1 and 13SS-2.
- Benzo[b]fluoranthene in GRSB-17, 13SS-1, 13SS-2, 13SS-7, and 13SS-8.
- Benzo[k]fluoranthene in 13SB-1, GRSB-17, 13SS-1, 13SS-2, 13SS-6, 13SS-7, and 13SS-8.
- Chrysene in GRSB-17, 13SS-2, 13SS-7, and 13SS-8.
- Indeno[1,2,3-c,d]pyrene in 13SS-1.

Fluoranthene was detected in 13SS-1 at greater than 6.2 μ g/g. The MCP limit is 900 μ g/g.

Pesticides and PCBs

- Chlordane and dieldrin in GRSB-21, 13SS-1, 13SS-2, and 13SS-5.
- Heptachlor epoxide in GRSB-21 and 13SS-5.
- DDD and DDE in 13SS-2.
- DDT in 13SB-1.
- PCB 1260 in 13SS-5.

Endrin was detected in GRSB-21 at greater than 0.5 μ g/g. The MCP limit is 6 μ g/g.

Metals

- Arsenic in 13SS-5.
- Beryllium in 13SB-2, 13SB-3 at 2 ft bgs, GRSB-17, GRSB-21, 13SS-1, 13SS-3, 13SS-6, and 13SS-7.
- Lead in 13SS-1, 13SS-2, 13SS-5, and 13SS-8.

4.3.15 UNIT 14

Management Unit 14 is located in the south-central portion of the site and consists of a grassy area downgradient from the steam-generation facility. The site contains several aboveground fuel storage tanks.

Phase 2 sampling consisted of collecting three surface samples (14SS-1, 14SS-2, and 14SS-3) and four boring samples. The boring samples were collected from soil boring



14SB-1 at sampling depths ranging from ground surface to 16 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-25.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 14 samples (all sample depths are 0 ft bgs):

Pesticides and PCBs

Chlordane and dieldrin in 14SS-1.

Metals

Beryllium in 14SB-1 and 14SS-1.

4.3.16 UNIT 15

Management Unit 15 is located along the southeastern boundary of the facility, downgradient of Units 13 and 14. The area is covered with grass and trees.

Phase 2 sampling consisted of collecting and analyzing four boring samples from two soil borings (15SB-1 and 15SB-2). Sampling depths ranged from ground surface to 8 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-26.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 15 samples (all sample depths are 0 ft bgs):

PAHs

Benzo[b]fluoranthene and chrysene in 15SB-2.

Pesticides and PCBs

- Dieldrin in 15SB-1 and 15SB-2.
- DDT in 15SB-2.

Metals

Lead in 15SB-2.

4.3.17 UNIT 16

Management Unit 16 is located in the southeast corner of the facility and includes the propellant storage bunker and in areas downgradient of the bunker. The unit is covered with grass and trees.



Phase 2 sampling consisted of collecting two surface samples (16SS-1 and 16SS-2) and two boring samples. The boring samples were collected from soil boring GRSB-24 at sampling depths ranging from ground surface to 12 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-27.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 16 samples (all sample depths are 0 ft bgs unless noted):

Pesticides and PCBs

- Chlordane in 16SS-1 and 16SS-2.
- Heptachlor epoxide and PCB 1260 in 16SS-2.

Metals

Beryllium in GRSB-24 at 12 ft bgs and 16SS-2.

4.3.18 UNIT 17

Management Unit 17 is located adjacent to the Charles River on the south side of Beacon Street. This area is currently used as a public recreation area; however, historical records indicate that it was once used by the facility. The area is covered by grass and trees.

Phase 2 sampling consisted of collecting 12 boring samples from six soil borings (17SB-1, 17SB-2, 17SB-3, GRSB-19, GRSB-22, and GRSB-23). Sampling depths ranged from ground surface to 16 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-28.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 17 samples (all sample depths are 0 ft bgs unless noted):

PAHs

- Benzo[a]anthracene, benzo[b]fluoranthene, and benzo[k]fluoranthene in 17SB-2, 17SB-3, GRSB-22, and GRSB-23.
- Benzo[a]pyrene in 17SB-2 and 17SB-3.
- Chrysene in 17SB-2, 17SB-3, GRSB-22, and GRSB-23 at 0 and 4 ft bgs.
- Indeno[1,2,3-c,d]pyrene in 17SB-2 and 17SB-3.

Fluoranthene and pyrene were detected in 17SB-2 at greater than 6.2 μ g/g. The MCP limits are 900 μ g/g and 700 μ g/g, respectively.

As Figure 4-4 indicates, the parameters could be attributed to fill material.



Pesticides and PCBs

- Chlordane in 17SB-1, GRSB-19, and GRSB-22.
- Dieldrin in 17SB-3 at 0 and 14 ft bgs and GRSB-22.
- DDE and DDT in 17SB-3.

Metals

- Beryllium in 17SB-1 at 0 and 6 ft bgs, 17SB-2 at 0 and 8 ft bgs, 17SB-3 at 0 and 14 ft bgs, GRSB-19 at 0 and 9 ft bgs, and GRSB-22 and GRSB-23 at 0 and 4 ft bgs.
- Lead in 17SB-1 and GRSB-23 at 4 ft bgs.

4.3.19 UNIT 18

Management Unit 18 consists of the yacht club located downgradient of the facility, adjacent to the Charles River on the south side of Beacon Street. This area is currently used as a facility for boats, boat painting, and repair.

Phase 2 sampling consisted of collecting and analyzing four boring samples from two soil borings (18SB-1 and GRSB-11). Sampling depths ranged from ground surface to 16 ft bgs. Laboratory analytical results for detected parameters are presented in Table 4-29.

The following chemicals were detected at concentrations exceeding the MCP Method 1 Soil Standards in Unit 18 samples (all sample depths are 0 ft bgs unless noted):

PAHs

- Benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, and chrysene in GRSB-11 at 0 and 6 ft bgs.
- Benzo[a]pyrene in GRSB-11.

The following PAHs were reported at greater than concentrations:

- Acenaphthylene in GRSB-11 at >12 μ g/g. The MCP limit is 100 μ g/g.
- Anthracene in GRSB-11 at >6.2 μ g/g. The MCP limit is 1,000 μ g/g.
- Fluoranthene in GRSB-11 at >6.2 μ g/g. The MCP limit is 900 μ g/g.
- Phenanthrene in GRSB-11 at >12 μ g/g. The MCP limit is 1,000 μ g/g.
- Pyrene in GRSB-11 at >6.2 μ g/g. The MCP limit is 700 μ g/g.

Pesticides and PCBs

Dieldrin in GRSB-11.



Metals

- Beryllium in 18SB-1 at 14 ft bgs and GRSB-1 at 0 and 6 ft bgs.
- Lead in GRSB-11.

4.4 GROUNDWATER SAMPLING RESULTS

WESTON completed one groundwater sampling round between 10 December and 16 December 1991 as part of the Phase 2 RI. Groundwater samples were collected from all 26 on-site monitor wells and five off-site upgradient wells. Laboratory analysis of these samples was completed for TCL organic compounds, TAL metals, cyanide, and the following radiologic parameters: gross alpha, gross beta, and uranium isotopes U-234, U-235, and U-238. In addition, groundwater samples from selected wells were analyzed for nitrates and explosive-related compounds.

Results from the Phase 2 groundwater sampling and, to a lesser extent, the Phase 1 groundwater sampling (conducted in February 1990 by ADL) were used to identify groundwater contamination and delineate contaminant distribution.

To assess groundwater quality, analytical results were divided into four groups based on monitor well location. Wells were grouped into zones as follows:

- Upgradient wells at the northern end and north of the site: MW-9, MW-10, MW-13, MW-22, MW-23, and deep well MW-16A. Wells north of the site whose upgradient status is uncertain because of nearby groundwater mounding: MW-16 and MW-24.
- Wells located at the western end of the site: MW-1, MW-2, MW-14, MW-15, and MW-17 and deep wells MW-15A, MW-17A, and MW-21.
- Wells located in the central portion of the site: C-2, MW-3, MW-4, MW-8, MW-12, MW-19, and MW-19B and deep wells MW-19A and MW-20.
- Wells located at the southeastern end of the site: C-3, MW-5, MW-6, MW-7, MW-11, and MW-18.

Monitor well locations are shown in Figure 4-9.

In the area of the wells north of the site, topography is essentially flat. Depth to bedrock (where deep well MW-16A was completed) in this area is approximately 42 ft bgs. Some of the wells are located at the northern site fence line (MW-9, MW-10, MW-13). The remainder (MW-16, MW-16A, MW-22, MW-23, MW-24) are located across Arsenal Street from the facility.

Regional groundwater flow in this area is to the south; however, groundwater mounding in the vicinity of Arsenal Street has created localized groundwater flow from Arsenal Street to the north towards wells MW-16, MW-16A, and MW-24. Groundwater



from the northern side of the mound flows to the north and then east in this area, while groundwater from the southern side of the mound flows to the south and east. The northern component of the flow is evident in only a small portion of the study area. The precise location of the mound has not been identified. Groundwater flow direction and the significance of the localized mounding are discussed in Subsection 3.6.2.1 of this report.

All upgradient wells with the exception of MW-16A are water table wells (see Subsection 2.4). MW-16A is a deep well completed to the bedrock surface in order to provide background data for this deeper groundwater zone.

In wells located at the western end of the site, topography is essentially flat. Depth to bedrock (where deep wells were completed) in this area is approximately 60 ft bgs. Groundwater flow is to the south, towards North Beacon Street. Data collected from these wells are used primarily to provide a profile of groundwater (and contaminant) movement in the western portion of the site, as well as to monitor the impacts of operations in western buildings (241, 243, 246, 39, 292/97) on the downgradient groundwater (both shallow and deep).

Wells located in the central portion of the site are intended to provide information on the aquifer characteristics of the shallow and deep groundwater in this area. Depth to bedrock in this area is approximately 100 ft bgs. C-2, MW-19A, and MW-19B are intended to monitor the deep groundwater. MW-3, MW-4, MW-8, and MW-12 serve to monitor the water table zone. Groundwater flow in this area is to the southeast.

Wells in the southeastern portion of the site are intended to monitor the groundwater downgradient of the eastern half of the site. The surface elevation in this area is lower than in the other three areas and topography is sloped to the south. Groundwater flow is to the southeast. Depth to bedrock is approximately 120 ft bgs in this area.

In discussing groundwater analytical results, concentrations of reported contaminants were compared to MCP Method 1 groundwater standards (310 CMR 40) and to Massachusetts Groundwater Quality Standards (MAGW 314 CMR 60). An assessment of groundwater quality within each zone is presented below.

4.4.1 UPGRADIENT WELLS

Groundwater beneath MTL is hydraulically downgradient of numerous industrial and commercial operations, located along and north of Arsenal Street, that could impact the quality of groundwater flowing onto the MTL site. Existing operations in the area that could affect groundwater quality include an automobile gasoline station, an electronics manufacturer, an auto body shop, an ironworks, and a steel fabrication shop. Past operations include the Hood Rubber Company and the Water Proof and Varnish Company. Approximate groundwater flow (and contaminant migration) paths are presented in Figures 3-9 and 3-10.



Phase 1 groundwater monitoring results indicated TCE in MW-13 at a concentration of 27.3 μ g/L. The pesticide DDT was reported in MW-10 and MW-13 at concentrations of 0.710 and 0.320 μ g/L, respectively. No other organic compounds were reported in upgradient wells. Manganese was reported above the federal secondary MCL of 50 μ g/L in MW-9 (124 μ g/L) and MW-10 (63 μ g/L).

Results from the Phase 2 groundwater sampling of the upgradient wells are discussed below. Laboratory analytical results for detected parameters are presented in Table 4-30.

4.4.1.1 Organics

VOCs

With the exception of MW-9, detectable quantities of VOCs were found in all upgradient monitor wells. Upgradient VOC concentrations were variable; however, analytical results indicated that few exceeded state groundwater standards. The following VOCs exceeded the MCP Method 1 groundwater standards in upgradient wells:

- 1,1-Dichloroethylene in MW-22 at 27 μ g/L.
- Carbontetrachloride in MW-22 at 23 μg/L.
- Benzene in MW-22 greater than 3,000 μ g/L. The MCP standard is 2,000 μ g/L, and the MAGW standard is 5 μ g/L.

The following chemicals exceeded the Massachusetts Groundwater Quality Standards (MAGW):

- Ethylbenzene in MW-23.
- Tetrachloroethylene in MW-13.
- Trichloroethylene in MW-16A.
- Xylenes in MW-23.

Tetrachloroethylene was also detected at a concentration exceeding the MAGW standard in well MW-16, whose status as an upgradient well is uncertain.

The following compounds were reported with greater than concentrations:

- 1,1,1-Trichloroethane in MW-22 at greater than 100 μ g/L. The MCP standard is 4,000 μ g/L and the MAGW standard is 200 μ g/L.
- Toluene in MW-23 at greater then 3,000 μ g/L. The MCP standard is 6,000 μ g/L and the MAGW standard is 2,000 μ g/L.

To more precisely determine the concentrations of benzene, 1,1,1-trichloroethane, and toluene, WESTON had proposed to dilute the sample and reanalyze using a higher



detection limit; however, the holding time would have been exceeded, so reanalysis was not completed.

The following VOCs were also detected, although no state standards were exceeded:

- 1.1-Dichloroethane in MW-22.
- 1,2-Dichloroethylene in MW-13.
- 1,1,1-Trichloroethane in MW-24.
- Trichloroethylene in MW-10 and MW-13.

Benzene, ethylbenzene, and toluene are typically associated with gasoline. MW-23 is located adjacent to a service station.

SVOCs

SVOCs were found in only one upgradient monitor well, MW-23. Analytical results showed greater than 100 μ g/L of naphthalene and 40 μ g/L of 2-methylnaphthalene in MW-23. The MCP standards for naphthalene and 2-methylnaphthalene are 6,000 μ g/L and 10,000 μ g/L, respectively. As was true with the VOCs detected in MW-23, the SVOCs found in MW-23 are typically associated with petroleum products.

Pesticides/PCBs

Pesticides detected in upgradient wells did not exceed either the MCP or MAGW groundwater standards, but their presence is indicative of upgradient application of pesticide compounds. Aldrin was detected in all but one upgradient monitor well, with the highest concentration (0.0176 μ g/L) in MW-13. Other detected pesticides include alpha-BHC in MW-22 and MW-23; alpha-endosulfan in MW-13; delta-BHC in MW-22 and MW-23; heptachlor in MW-13; heptachlor epoxide in MW-13; isodrin in MW-13; lindane (gamma-BHC) in MW-10 and MW-22; DDD in MW-23 and DDT in MW-09. State standards currently exist for aldrin (MCP - 0.5 μ g/L) and lindane (MAGW - 4 μ g/L).

PCBs were not detected in any of the groundwater samples collected from upgradient wells.

Of the northern wells not considered upgradient, aldrin was detected in both MW-16 and MW-24, and delta-BHC was detected in MW-16.

Explosives

Explosives-related compounds were not detected in groundwater samples collected from upgradient monitor wells.



4.4.1.2 Inorganics

Phase 2 groundwater analytical results reported detectable quantities of the following TAL metals in upgradient wells: aluminum, barium, calcium, chromium, copper, iron, magnesium, manganese, potassium, sodium, and zinc. In addition, cyanide and nitrite/nitrate (nonspecific) were detected.

Although no inorganics detected in upgradient wells exceeded any MCP groundwater standards, the following inorganics exceeded MAGW standards:

- Iron in MW-23.
- Manganese in MW-16A and MW-23.
- Nitrite/nitrate (nonspecific) in MW-16A and MW-23.
- Sodium in MW-09, MW-10, MW-13, and MW-23.

4.4.1.3 Radiologic Results

Upgradient concentrations of radiologic parameters were reported as follows:

- Gross alpha activity ranged from 1 pCi/L in MW-9, MW-16A, and MW-23 to 11 pCi/L in MW-10. The MAGW standard of 15 pCi/L was not exceeded in any upgradient monitor wells.
- Gross beta activity ranged from 1 pCi/L in MW-9 to 21 pCi/L in MW-13. The MAGW standard for gross beta activity is equal to a dosage of 4 millirems per year (mrem/yr). Comparing observed beta emission with the MAGW standard involves converting from pCi/L (concentration) to mrem/yr (dosage); however, conversion between pCi/L and mrem/yr is a function of isotope(s) present, which is not known. In 51 FR 34836, there is a table that specifies concentrations for various isotopes in drinking water in pCi/L that would result in a dose rate of 4 mrem/yr. The range for beta emitters was 50 to 20,000,000 pCi/L. The beta activity for the most limiting isotope, 50 pCi/L, was not exceeded.
- Total uranium, which is measured as the sum of U-238, U-235, and U-234, ranged from bdl to 1.3 pCi/L. The MAGW standard for total uranium of 10 pCi/L was not exceeded in any upgradient wells.

4.4.2 WESTERN WELLS

Groundwater from eight monitor wells located at the western end of the site was sampled to assess the effects of Laboratory Buildings 39 and 292, hazardous materials storage buildings, and machine shops. Results from shallow wells MW-1, MW-2, MW-14, MW-15, and MW-17 were used to assess groundwater quality near the water table, while deep wells MW-15A, MW-17A, and MW-21 assessed water quality near the soil/bedrock interface. Western monitor well locations are shown in Figure 4-8.



No organic compounds detected during Phase 1 were found to exceed MCP groundwater standards. Regarding inorganic parameters, cadmium (31 μ g/L) was detected in MW-2 at concentrations greater than the MAGW standard of 10 μ g/L. Lead was detected in monitor wells MW-1 (50 μ g/L) and MW-17 (54 μ g/L). No other inorganic parameters were found to exceed MCP or MAGW standards.

Results from the Phase 2 groundwater sampling of the western wells are discussed below. Laboratory analytical results for detected parameters are presented in Table 4-31.

4.4.2.1 Organics

VOCs

VOCs were found in seven of the eight western monitor wells. The only western well not reporting VOCs was MW-2.

Although no VOCs detected in western wells exceeded any MCP groundwater standards, the following VOCs exceeded MAGW standards:

- Tetrachloroethylene in MW-15, MW-15A, MW-17A, and MW-21.
- Trichloroethylene in MW-15, MW-17A, and MW-21.

Acetone was detected in MW-17A at greater then 100 μ g/L. The MCP standard is 50,000 μ g/L, and the MAGW standard is 700 μ g/L.

SVOCs

No SVOCs were detected in groundwater samples collected from western wells.

PCBs/Pesticides

Pesticides were detected in seven of eight western monitor wells. Where possible, reported concentrations were compared to available groundwater standards; however, standards have not been established for many pesticides encountered. Detected pesticides did not exceed available MCP or MAGW standards.

PCBs were not detected in any groundwater samples collected from western wells.

Explosives

Nitroaromatic compounds were not detected in any western monitor wells.

4.4.2.2 Inorganics

Thirteen metals and cyanide were detected in western wells. Lead in MW-15A at a concentration of $45 \,\mu\text{g/L}$ was the only inorganic exceeding MCP groundwater standards.



The MCP standard for lead (category GW-3) is 30 μ g/L. The following inorganics exceeded MAGW standards:

- Cadmium in MW-02.
- Chromium in MW-02.
- Lead in MW-17.
- Manganese in MW-01, MW-15, and MW-21.
- Sodium in MW-01, MW-02, MW-14, MW-15, MW-15A, MW-17A, and MW-21.

4.4.2.3 Radiologic Parameters

The highest alpha activity in groundwater collected from western wells was 21 pCi/L in MW-2, which exceeded the MAGW standard of 15 pCi/L. No other samples exceeded the MAGW standard for alpha activity.

Beta activity in western wells ranged from 5 pCi/L in MW-15 and MW-17 to 110 pCi/L in MW-15A. MW-17A (110 pCi/L) had a high natural potassium content (80.3 mg/L). A small but constant fraction of potassium is naturally radioactive. The activity of the radioactive potassium at MW-17A was calculated to be 67 pCi/L. The annual dose from this concentration of radioactive potassium is 0.9 mrem/yr using the conversion factors in 51 FR34836. The MAGW standard for beta activity is 4 mrem/yr.

Total uranium ranged from 0.2 pCi/L in MW-1 to 2.4 pCi/L in MW-15. All concentrations were well below the MAGW standard of 10 pCi/L.

4.4.3 CENTRAL WELLS

Central wells were sampled to assess the impacts to groundwater from the following sources: Building 43 (foundry and DU incineration), Building 313 (metal plating), and Building 312 (metal plating, DU and beryllium machine shops). Shallow wells C-2, MW-3, MW-4, MW-8, MW-12, MW-19, and MW-19B were sampled to assess water quality in the upper aquifer, while deep wells MW-19A and MW-20 were sampled to assess groundwater quality at the soil/bedrock interface. Central monitor well locations are shown in Figure 4-9.

In Phase 1, well C-2 contained concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX) compounds. In MW-8, vinyl chloride and PCE were detected. Well C-2 also reported several fuel-related SVOCs.

Results from the Phase 2 groundwater sampling at the central wells are discussed below. Laboratory analytical results for detected parameters are presented in Table 4-32.



4.4.3.1 Organics

VOCs

VOCs were detected in eight of nine central wells. The only well not reporting VOCs was MW-4. Although no VOCs detected in central wells exceeded any MCP groundwater standards, the following VOCs exceeded MAGW standards:

- Benzene in C-2.
- Ethylbenzene in C-2.
- Tetrachloroethylene in MW-8, MW-19A, and MW-20.
- Trichloroethylene in MW-8 and MW-19B.
- Toluene in C-2.
- Xylenes in C-2.

SVOCs

SVOCs were detected in three of nine central monitor wells. Benzo[a]anthracene, in MW-19A and MW-20, was the only SVOC exceeding MCP groundwater standards. Naphthalene was detected in C-2 at greater than 100 μ g/L. The MCP standard for naphthalene is 6,000 μ g/L. No SVOC exceeded MAGW standards.

PCBs/Pesticides

Low concentrations of pesticides were found in all nine central wells. Observed concentrations were below the groundwater standards that have been established.

The most widespread pesticide found was aldrin, which was detected in all monitor wells except MW-3. Concentrations of aldrin ranged from a low of $0.014~\mu g/L$ in MW-8 to a high of $0.0813~\mu g/L$ in well C-2. The MCP groundwater standard for aldrin of $0.5~\mu g/L$ was not exceeded.

Other pesticides that were found in several wells include alpha-BHC, reported in MW-3, MW-8, and MW-20 at concentrations ranging from 0.020 to 0.0065 μ g/L, and delta-BHC, reported in MW-3, MW-8, and MW-20 at concentrations ranging from 0.0038 μ g/L to 0.253 μ g/L. DDT was found in three wells at concentrations ranging from 0.013 to 0.28 μ g/L. Groundwater standards have not been established for any of the above pesticides.

PCBs were not found in any central monitor wells.

Explosives

Nitroaromatic compounds were not found in any groundwater samples collected from central wells.



4.4.3.2 Inorganics

Selenium in MW-19B was the only inorganic exceeding MCP groundwater standards. The following inorganics exceeded the MAGW standards:

- Iron in C-2.
- Manganese in C-2, MW-3, MW-8, MW-19A, MW-19B, and MW-20.
- Nitrite/nitrate (nonspecific) in MW-20.
- Sodium in C-2, MW-3, MW-4, MW-8, MW-12, MW-19, MW-19A, MW-19B, and MW-20.

4.4.3.3 Radiologic Parameters

The maximum alpha activity in groundwater collected from central wells was 13 pCi/L in wells C-2 and MW-19B. The MAGW standard of 15 pCi/L was not exceeded in any central well.

Beta activity in groundwater collected from central wells ranged from 8 pCi/L in MW-3 to 27 pCi/L in MW-20; however, the lowest concentration that could result in a dose of 4 mrem/yr for the most limiting beta emitter in 51 FR 3983F (50 pCi/L) was not exceeded.

All concentrations were below the MAGW standard of 10 pCi/L. The maximum total uranium concentration was 2.2 pCi/L in MW-3.

4.4.4 SOUTHEASTERN WELLS

These wells are located downgradient of the commander's quarters, the propellant storage area, the oil-tank farm, and operations in the central portion of the site. The southeastern wells include five Phase 1 wells (C-3, MW-5, MW-6, MW-7, and MW-11) and one Phase 2 well (MW-18). All southeastern monitor wells are shallow-screened and are used to assess groundwater quality in upper portions of the aquifer. Southeastern monitor well locations are shown in Figure 4-9.

During Phase 1 groundwater sampling, several chlorinated solvents were detected in MW-6. With respect to inorganics, MW-5, MW-6, and C-3 contained concentrations of iron and manganese above MAGW standards.

Results from the Phase 2 groundwater sampling at the southeastern wells are discussed below. Laboratory analytical results for detected parameters are presented in Table 4-33.

4.4.4.1 <u>Organics</u>

VOCs

VOCs were identified in one of the southeastern wells, MW-11. PCE was reported at a concentration of 1.48 μ g/L, and TCE was reported at a concentration of 1.5 μ g/L. The state groundwater standards were not exceeded.



SVOCs

No SVOCs were reported in the southeastern monitor wells.

PCBs/Pesticides

Pesticides were found in all southeastern monitor wells. The pesticide aldrin was found in all wells at concentrations ranging from 0.0142 μ g/L in MW-18 to 0.0262 μ g/L in MW-5; however, the MCP groundwater standard of 0.5 μ g/L was not exceeded. Other pesticides found on-site in southeastern wells include DDE, DDT, and delta-BHC. No standards have been established for these pesticides.

PCBs were not found in any of the southeastern monitor wells.

Explosives

The explosive 1,3,5-trinitrobenzene was reported in MW-6. No standard for 1,3,5-trinitrobenzene has been established. MW-6 is located immediately outside of the propellant storage bunker.

4.4.4.2 <u>Inorganics</u>

Although no inorganics detected in southeastern wells exceeded any MCP groundwater standards, the following inorganics exceeded MAGW standards:

- Iron in MW-6.
- Lead in MW-6.
- Manganese in MW-5, MW-6, MW-11, and MW-18.
- Nitrite/nitrate (nonspecific) in C-3.
- Sodium in C-3, MW-6, MW-11, and MW-18.

4.4.4.3 Radiologic Parameters

Alpha activity in MW-11 (26 pCi/L) and MW-7 (18 pCi/L) exceeded the MAGW standard of 15 pCi/L.

Beta activity in western wells ranged from 5 pCi/L in well C-3 to 23 pCi/L in MW-11. The concentration that would result in a dose of 4 mrem/yr for the most limiting beta emitter in 51 FR 3983F (50 pCi/L) was not exceeded.

The maximum total uranium concentration was 2.4 pCi/L in MW-11. All concentrations were below the MAGW standard of 10 pCi/L.

4.5 CHARLES RIVER SAMPLING RESULTS

Surface water and/or sediment samples were collected at 19 stations in the Charles River in the vicinity of the MTL site during the Phase 2 RI. Five stations were located upstream of the MTL storm sewer outfalls to provide background surface water and sediment chemistry data. Fourteen stations (nine for surface water) were located at or



downstream of MTL. The locations of all Charles River samples are shown in Figure 4-10.

In the discussion of the results, the Charles River surface water data are compared with available EPA and Commonwealth of Massachusetts criteria for the protection of aquatic life. Charles River sediment data are compared with available National Sediment Quality Criteria values (which are currently in draft form). Currently, only five compounds (acenaphthene, fluoranthene, phenanthrene, dieldrin, and endrin) have sediment quality criteria values. Table 4-34 lists field measurements made during the Charles River investigation. The results of 1993 Charles River sampling will be discussed in the Addendum to the RI, which contains the Environmental Evaluation.

4.5.1 UPSTREAM

Three stations (18, 19, and 20) were located along the southern edge of the island, and one station each was located upstream of the site in the mid-channel (2) and near the yacht club (3). The upstream stations were sampled to provide information on the existing surface water and sediment chemistry to compare with the site-related stations. Parameters detected in samples collected at the upstream stations included eleven inorganic parameters (aluminum, barium, beryllium, calcium, copper, iron, magnesium, manganese, potassium, sodium and zinc), one semivolatile organic compound (bis(2-ethylhexyl)phthalate), and two pesticides (isodrin and lindane) (see Table 4-35). Another organic, methylene chloride, was detected in one of the duplicate samples but not in the initial sample. Surface water data were compared to EPA and Commonwealth of Massachusetts water quality criteria.

The following chemicals exceeded the EPA water quality criteria:

- Bis(2-ethylhexyl)phthalate at SW-20 for the protection of freshwater aquatic life (both acute and chronic levels).
- Copper at SW-20 (total) and SW-2 (soluble) for the protection of freshwater aquatic life (both acute and chronic levels).

No other analytes exceeded criteria concentrations at the upstream stations.

Sediment chemistry results established upstream concentrations for VOCs, BNAs, metals, TOC, and radiological parameters. In the upstream sediment samples, 19 inorganic parameters, 15 BNAs/PAHs, and 5 pesticides were detected. Low levels of uranium, gross alpha activity, and gross beta activity were also measured. No VOCs were detected. The analytical results for the upstream sediment samples are listed in Table 4-36. Upstream sediment samples were dark with evidence of long-term organic deposits (e.g., oil residue). This observation is substantiated by the fact that 15 BNA/PAH compounds were detected in these upstream sediments. The presence of these compounds reflects the use of this portion of the river by marine traffic for many years. Figure 4-10 shows the location of the yacht club with respect to the Phase 2 river samples.



4.5.2 DOWNSTREAM

Surface water results from the downstream sampling stations (6, 7, 8, 9, 11, 13, 15, 16, and 17) were compared to EPA and Massachusetts surface water quality criteria for the protection of aquatic life. The only chemical that exceeded EPA water quality criteria was bis(2-ethylhexyl)phthalate in SW-7.

The analytical results for the downstream surface water samples are presented in Table 4-38. The upstream and downstream Charles River surface water sample results were compared to identify differences. Chromium was the only inorganic parameter detected downstream that was not detected at the upstream stations.

Five organic compounds (toluene, TCE, ethylbenzene, xylenes, and 1,3-dimethylbenzene) were detected at downstream stations but not at the upstream stations. It is likely that some of this contamination, especially fuel-related compounds (toluene, ethylbenzene, and xylenes), can be attributed to the fuel-related activities (i.e., filling fuel tanks on boats, etc.) on the river. Bis(2-ethylhexyl)phthalate, detected at the upstream station 20 (at 61.6 μ g/L), was detected in only one downgradient sample (Station 7 at 33.7 μ g/L). Since the upgradient concentration is greater, the data suggest that this contaminant is not related to the site.

No pesticides were detected in downstream locations that were not also detected in upstream locations. Two pesticides, isodrin and lindane, were detected in both upstream and downstream locations. The water quality criteria (available for lindane only) were not exceeded.

The total uranium activity of 1.4 pCi/L in SW-8 exceeded 1.0 pCi/L, which is considered a typical uranium activity level in surface water (Richmond, 1988).

A total of 54 analytes were detected in the downstream sediment samples, including 20 TAL metals, 21 BNAs, cyanide, and 12 pesticides. Six BNAs (anthracene, dibenz(a,h)anthracene, dibenzofuran, indeno(1,2,3,-c,d)pyrene, 1,2-dichlorobenzene, and naphthalene), one metal (silver), cyanide, and seven pesticides (aldrin, beta-endosulfan, delta-benzenehexachloride, endrin, heptachlor epoxide, isodrin, and lindane) were detected in downstream sediments, none of which was detected at the upstream stations.

The results of the downstream sediment samples (Table 4-39) were compared to available National Sediment Quality Criteria values (currently in draft form) and upstream sediment concentrations. The values for the National Sediment Quality Criteria are calculated for each sample based on the organic carbon concentration at each sampling location. The calculations for the Charles River sediment locations are presented in Table 4-37. Phenanthrene was detected above the criteria in SD-4, SD-5D, and SD-5P.



In summary, the Charles River, both upstream and downstream from the site, is extensively contaminated, which reflects the long-term use of the river by industry and marine traffic. The site is not significantly impacting the river with radioactive contamination. These results are evaluated further in the Baseline Risk Assessment (Section 6) and the Environmental Evaluation (Section 7).

4.6 STORM SEWER INVESTIGATION

4.6.1 STORM SEWER MONITORING RESULTS

Flow monitoring and sampling of surface runoff at MTL were conducted on 12 December 1991. A rain event occurred between midnight and 1300 hours on that date. The recording rain gauge installed on the roof of Building 652 recorded a total of 0.27 inches of rainfall during that period, with the majority of rainfall (0.21 inches) occurring between 700 and 1200 hours. A summary of the recorded rainfall and the flow rates measured at each of the monitoring locations is presented in Table 4-40.

The first effects of this rain event, an increase in flow in the stormwater collection system, were seen between 700 and 900 hours. The lag period that elapsed before any visible increase in resultant flow is primarily a function of the distance of the monitoring station from the bulk of the stormwater collection system. Flows were seen to increase at approximately the same time throughout the collection system.

Response of flow rate to rainfall amount is primarily a function of the size and nature of the area served by the collection system. The largest increases in flow were seen at Outfalls 1 (SW-4P) and 2 (SW-5P) and Background 1 (SW-1).

Flows measured at Outfall 1 (SW-4P) originated from both runoff on-site and runoff from north of the site (measured at Background 1), so a large increase in flow was expected at this location. Flows were observed at Background 1 during the installation of the instrumentation, even in the absence of precipitation or runoff. This baseline flow, which was measured at 9 gpm, is attributed to groundwater infiltration or other hookups into the off-site stormwater collection system. Flows at Background 1 (SW-1) increased rapidly in response to the rain event. The flow rate of 509 gpm, recorded between 800 and 900 hours, is believed to be an erroneous measurement. This may have been caused by an obstruction in the line segment downstream of Background 1 (SW-1), which caused ponding of flow at the monitoring location. Upon relief of this condition, recorded flows appeared to be in the expected range. The maximum recorded flow rate was 488 gpm.

Since Outfall 1 (SW-4P) is located on the same major segment of the stormwater collection system as Background 1 (SW-1), a similar flow pattern would be expected, and was observed, at this location. Baseline flows, which originated upstream of Background 1, were identical at Outfall 1 (SW-4P). Flows increased more sharply at Outfall 1 than at Background 1 (SW-1), which was attributed to the collected runoff from parking lots and rain gutters on the MTL site. An increase in flow of



approximately 125 gpm was measured across the site. The maximum flow rate recorded at Outfall 1 (SW-4P) was 428 gpm.

The central portion of the site is served by those segments of the collection system that ultimately pass through Outfall 2 (SW-5P). The increase in flow measured at Outfall 2 can be attributed to the large paved areas and numerous buildings with rain gutters and downspouts in this portion of the site that readily discharge to the stormwater collection system with little or no percolation of runoff to surface soils. Flows at Outfall 2 (SW-5P) increased rapidly in response to precipitation. For most of the monitoring period, flows at Outfall 2 (SW-5P) averaged approximately 60 gpm. A maximum flow rate of 92 gpm was recorded just prior to deactivation of the instrumentation at 1100 hours.

Although the area served by those segments of the collection system that ultimately discharge to Outfall 5 (SW-10P) is one of the largest on the site, it consists mostly of grass. Flows measured at Outfall 5 (SW-10P) reflect this fact, increasing more gradually than at most of the other locations. This is because a portion of the runoff percolates to the soils. Flows increased to a maximum rate of 24 gpm and then stabilized to an average of approximately 22 gpm, which is a fraction of the flow measured at the other locations.

Flows measured at Outfall 3 (SW-7P) were rather insignificant in comparison to flows measured at other locations. While a maximum rate of 27 gpm was measured at the start of the rainfall event at this location, flows measured during the rest of the rain event averaged approximately 5 gpm. This relatively small discharge is attributed to the limited drainage area served by those segments of the collection system that discharge to Outfall 3 (SW-4P).

A significant increase in flow was measured by the instrumentation at Outfall 7 (SW-14P). Due to the obstruction in the outfall pipe discussed previously, these measurements are viewed as erroneous. The instrumentation calculates flow on the basis of depth of flow. Since the only outlet to this location was blocked, the level of water at the mouth of the outfall continued to rise during the rain event. It is unlikely that any discharge actually occurred during the monitoring period. Instantaneous flow measurements taken from contributory lines revealed that flows at this location averaged approximately 5 gpm.

Flows measured at Background 2 (SW-21) remained fairly constant during the monitoring period. During the installation of the instrumentation (at which time there was no precipitation or runoff), a significant amount of clear, cold flow was observed at this location. This could result from possible groundwater infiltration or other hookups into the public stormwater collection system; however, an increase in flow during the precipitation event would be expected as a result of surface runoff. For an undetermined reason, this did not occur. Flow rates remained fairly constant (approximately 30 gpm) both before and during the precipitation event.



4.6.2 RESULTS OF SAMPLING PROGRAM

Samples were collected in conjunction with the rain event and the subsequent flow monitoring program, conducted on 14 December 1991. Sampling and flow monitoring were conducted in such a manner as to gather representative samples and flow rates that would occur as a result of a typical precipitation event; however, the occurrence of several minor snowfalls (<1 inch) and the associated intermittent runoff complicated the monitoring program. For proper monitoring of stormwater runoff, no runoff can occur within 72 hours of commencement of the sampling/monitoring program. The intermittent runoff from the melting snow delayed the start of the sampling/monitoring program for several days. In addition, it is virtually impossible to precisely forecast the start of a rain event. Both of these factors resulted in numerous "false starts" of the sampling/monitoring program.

Sampling and flow monitoring were conducted on 14 December 1991. The automatic composite samplers were programmed to begin sampling when an increase in flow was sensed by the flow meters. A grab sample was collected by the sampler during the initial period of runoff ("first flush"). This sample was analyzed for VOCs. The remaining sample was collected as a flow composite sample. Three individual aliquots were collected at predetermined flow intervals ranging from 50 gallons to 1,000 gallons. This flow composite sample was submitted for the remaining chemical parameters, which consisted of the following:

- Semivolatiles
- Pesticides
- PCBs
- Total metals
- Dissolved metals
- Cyanide
- Nitrates
- TOC
- Hardness
- Gross alpha and beta
- U-234, U-235, and U-238

It should be noted that no cyanide sample was submitted for Outfalls 3 (SW-7P), 5 (SW-10P), or 7 (SW-14P) due to insufficient amounts of sample. The analytical results are presented in Table 4-41.

In order to determine the extent of contamination originating on-site, analytical results from each of the outfalls were compared to the maximum value obtained from either of the two background locations.

The chemical parameters most commonly detected at the outfalls were metals. Arsenic, copper (total and soluble), iron (total and soluble), potassium (total and soluble), manganese (total and soluble), sodium (total and soluble), and zinc (total and soluble)



were detected at one or more of the outfalls. The presence of sodium and potassium may be attributed to deicing agents and road salt. Iron, copper, and zinc are rather ubiquitous materials, and their presence in the concentrations measured is not considered unusual. Arsenic was detected at Outfalls 1 (SW-4P), 3 (SW-7P), and 7 (SW-14P) and at the second background location. Manganese (total and soluble) was detected at both background locations and was also found in samples collected at Outfalls 1 (SW-4P) and 7 (SW-14P).

Cyanide was detected in water samples collected from both background locations and at Outfall 1. The concentration of cyanide detected in the Outfall 1 sample was slightly higher than the levels seen in either of the background samples. As was previously stated, no sample was submitted for cyanide analysis from Outfall 3 (SW-7P), 5 (SW-10), or 7 (SW-14P).

Nitrate was also detected at both background locations and at Outfall 2. While the concentration of nitrate $(1,100~\mu g/L)$ at Outfall 2 (SW-5P)was slightly higher than at either of the background locations, all concentrations listed are well within typical urban ranges.

A number of pesticides were detected at various outfalls that were not detected at either of the background locations. Those pesticides detected at Outfall 7 (SW-14P) only are as follows:

- Alpha-BHC
- Delta-BHC
- Chlordane

Several pesticides were detected in only one or two samples, such as beta-BHC in Outfall 3, methoxychlor in SW-4P, and heptachlor in Outfalls 2 and 7.

It should be noted that due to the blockage in the outfall pipe at Outfall 7 (SW-14P), transport of these pesticides to the Charles River would be impeded.

Several other pesticides were detected at either of the background locations and also at various outfall locations. For example, aldrin was detected at both Background 1 (SW-1) and Outfall 3 (SW-7P).

Several pesticides (aldrin, lindane, DDE, and DDT) were detected at Background 1 (SW-1) and again at Outfall 1 (SW-4P). This indicates that at least a portion of the levels of the pesticides detected at Outfall 1 (SW-4P) originated off-site, since Outfall 1 is located downstream of Background 1. This is also true of several of the other chemical parameters previously discussed.

Several chemical parameters whose identities could not be determined were detected at every outfall location.



4.7 INSPECTION AND DYE TESTING OF SEWERS

4.7.1 INTERNAL INSPECTION OF SANITARY AND STORM SEWERS

Internal inspection and cleaning of selected sanitary and storm sewers were conducted from 27 May through 2 June 1992. The storm sewer segments that were inspected are presented in Figure 4-11. The sanitary lines that were inspected are shown in Figure 4-12. Copies of all cleaning and inspection logs are presented in Appendix H.

Before any internal inspection of the pipe segments was conducted, each segment was thoroughly cleaned and flushed by means of a hydraulic jet. A specially designed nozzle located at the end of a high-pressure hose is propelled by pressurized water from the beginning of the line segment to the end of the line segment. This nozzle is then pulled back through the pipe while water pressure is maintained. This results in a "sweeping" action that directs any sediment and debris to the manhole at the beginning of the line segment. Any sediment is deposited at this manhole and manually removed.

Following the preparatory cleaning, the sewer sections were internally inspected to determine the location, condition, and estimated flow rate for each source of water. During the inspection, all the infiltration/inflow sources, structural defects, service connections, abnormal conditions, and other pertinent observations were recorded.

Internal inspection at MTL utilized a closed-circuit television camera to observe the condition in the sewer lines. The results were observed on a television monitor and documented by means of videotape and written logs.

Sanitary sewer segments which were cleaned and inspected consisted of (1) the trunk line that runs on the south side of MTL along North Beacon Street and across the southeast corner of MTL and (2) the portion of the sewer which runs along Arsenal Street north of the main entrance of MTL.

The sewer segments located along North Beacon Street (from MH 120 to MH 114) were found to be relatively free of sediment and debris. It was discovered from staff members of the Watertown Department of Public Works that this portion of the sanitary sewer had been previously cleaned and inspected in 1989. The sewer segments that run through the easement located along the southern parameter of MTL (from MH 114 to MH 53) were found to contain moderate to heavy sand deposits and a fair amount of oil. While the origin of the sand deposits could not be determined, it should be noted that there is very little slope associated with these sewer segments. This lack of slope will facilitate the deposition of sediment and debris due to the fact that flow in these segments will have a low scouring velocity.

The condition of all the sewer segments located along North Beacon Street and the southern boundary of MTL was relatively good. The only structural defects of note were a few relatively minor cracks along some of the pipe segments and at a few pipe joints. This is not considered to be unusual or excessive in vitrified clay pipe that has



been in place for over 20 years. No groundwater infiltration was observed, nor was there any evidence that groundwater infiltration had occurred in the past. Some minor root infiltration was observed in the pipe segments that run through the easement.

The sewer segments located on Arsenal Street contained a moderate amount of gravel and debris. Approximately two 5-gallon buckets of sediment were removed from each of the two sewer segments investigated at this location. The pipe was found to be in relatively good condition. As was the case with the other segments of the sanitary sewer, a few relatively minor cracks along some of the pipe segments and at a few pipe joints were observed. No groundwater infiltration was observed.

One other segment of the sanitary sewer system, the line that extends along Kingsbury Avenue, was scheduled to be investigated. This line was believed to be 8 inches in diameter, but was discovered actually to be 5 inches in diameter. A pipe with this small a diameter cannot be inspected with conventional television equipment. Therefore, this segment of the sanitary sewer system was not inspected.

Three storm sewer lines were also inspected as part of the internal inspection program. These three lines were designated as Drainline A (which extends from the north side of Building 311 to the outfall on the Charles River), Drainline B (which extends from the northwest corner of Building 36 to the southern perimeter of MTL), and Drainline C (which extends from the south side of Building 312 to the concrete embankment where the fuel oil tanks are located).

The majority of Drainline A consisted of iron pipe. Because of the durable nature of this type of pipe, the condition of these segments was very good. The downstream segments of Drainline A consisted of vitrified clay pipe. As was the case with other pipe segments that were constructed with vitrified clay pipe, a few relatively minor cracks were found in this portion of Drainline A.

Drainline B is constructed of vitrified clay pipe. Hairline cracks were found throughout the downstream portion of this sewer segment; however, no active groundwater infiltration was observed.

The majority of Drainline C consists of elliptical brick pipe, indicating that this pipe segment is probably the original pipe that was installed and is considerably older than the other two segments that were inspected. At the southernmost portion of this segment, the brick pipe was replaced with vitrified clay pipe, indicating either that the brick pipe had failed in the past or that this portion of the storm sewer system had been reconfigured. The entire segment inspected was found to be in relatively good condition with no signs of groundwater infiltration observed.

In summary, the majority of pipe that was investigated appears to be in relatively good condition, with some typical signs of age-related deterioration observed. No active groundwater infiltration was observed, nor was there any evidence that infiltration had occurred in the past.



4.7.2 DYE TESTING

As part of the Phase 2 investigation at MTL, dye tests were conducted on several floor drains to determine their destinations. Typically, these destinations were storm or sanitary sewer manholes or outdoor cisterns.

Floor drains that exhibited radiological contamination during instrument surveys or whose histories indicated possible contamination were dye-tested. These included the following:

- A hot sink drain on the fifth floor of Building 39.
- A floor drain behind an experimental furnace in Room 101A of Building 39.
- A shower drain in the Building 43 lean-to.
- Two floor drains in the open bay area of Building 43.
- A sink drain at the southeast wall of Building 43.
- A floor drain, a sink drain, and an eyewash station drain in Building 43.
- A sink drain in Room 244 of Building 292.
- A shower drain adjacent to the DU machining rooms in Building 312.
- A floor drain in one of the DU machining rooms in Building 312.

Dye testing generally involved introducing a fluorescent green or yellow dye into the floor drain and flushing the floor drain with tap water in order to transport the dye to its destination. Once the dye had been introduced, WESTON personnel observed all sanitary manholes that could receive flows from the building being tested. These manholes were determined using existing sanitary sewer maps. Generally, the floor drain outlets were located as shown on the sewer maps.

The results of the dye testing are presented in Table 4-42. In this table, floor drain destinations as determined during the dye tests are listed. The manholes are depicted in Figure 4-12. Figure 2-6 depicts the cistern draining Building 243.

According to existing maps and current knowledge, the floor drain in Room 101A of Building 39 could have emptied into sanitary Manhole 122. Upon examination of the manhole and the drain, it was noted that the manhole inlet was located at a higher elevation than the floor drain. No pumps were noted. Therefore, hydraulically speaking, Manhole 122 could not have received flows from the Room 101A floor drain. Dye testing of this manhole was conducted, regardless of this fact, in case the field



observations of the hydraulic levels of the drain and the manhole were incorrect. When fluorescent dye was poured into the drain and flushed with water, no response was noted at Manhole 122. The other possibility for the Room 101A drain was a manhole (Manhole 01) located on North Beacon Street. According to site maps, two 5-inch sewer lines exit Building 39 at the south side and join the MDC main 12-inch line beneath North Beacon Street. Dye testing confirmed that Building 39 flows do reach North Beacon Street at Manhole 01.

The three drains in Storage Building 243 were dye-tested, and all three were found to empty into the cistern adjacent to the building via a single pipe (although three pipes, each approximately 6 inches in diameter, culminate at the cistern). As a result of the dye tests, sediment samples were collected from selected manholes and analyzed for radiological parameters. Results are discussed below.

4.7.3 RADIOLOGICAL SEWER RESULTS

Sediment samples were taken from 12 sanitary sewer manholes for radiological analysis. The manhole identification numbers and the results of the radiological analyses of the samples are contained in Tables 4-43 and 4-44. Some chemical results are also presented for those instances where chemical analyses were requested. The locations of the manholes are shown on Figure 4-12. All of the manholes except 82 and 54 are for the municipal sanitary sewer lines that underlie North Beacon and Arsenal Streets. The extent of contamination observed during the Phase 2 RI is described here, but the description is not indicative of current conditions since much of the sewer line sediments have been removed.

Contamination of the sediment with DU is evident in several of the manholes. On Arsenal Street, Manhole 93 had higher than average uranium concentrations (55 pCi/g for U-238). This manhole is on the sanitary sewer line to which Building 43 drainlines discharge. Since the concentrations in the two manholes that are upstream of 93 (91 and 92) are comparable to background concentrations, it appears that the contamination in 93 is from Building 43. The contamination levels in the next downstream manhole that was measured, 95, is comparable to background (less than 1 pCi/g).

On North Beacon Street, above-background uranium concentrations were found in the sediment in Manholes 120, 01, 78, 67, 36, and 35. The isotopic ratios are indicative of DU; and some of the uranium concentrations in these manholes exceed the NRC limit of 35 pCi/g (see Table 4-3). Drainlines from buildings with known radiological contamination (Buildings 39, 292, and parts of 311, 312, and 313) flow into this line. The contamination in Manhole 120 is from an as yet unknown pathway.

4.8 RADIOLOGICAL INVESTIGATION OF BUILDINGS AND GROUNDS

The results of the radiological investigation covering the outdoor grounds and buildings are discussed in the following subsections. These results confirm the existence of



radioactive contamination in some buildings at MTL. The radiological survey data are contained in the Radiological Field Survey Report (WESTON, 1992a).

The discussion of building survey results has been divided into those buildings with extensive contamination (Buildings 43 and 312), those buildings with suspected contamination (Buildings 37, 39, 97, 241, 292, 311, and 313), and those buildings with no known use of radiological materials (Buildings 36, 60, 111, 117, 118, 131, 229, 243, and 656).

The building surface activity is compared with the NRC and Massachusetts surface activity limits presented in Subsection 4.1. These limits assume that uranium is the radioisotope of concern. Other radioisotopes have much lower limits. For example, the transuranics have a total alpha activity limit of 200 dpm/100 cm² and a removable alpha activity of 20 dpm/100 cm². There is no evidence from the isotopic analyses that were done on waste produced during decommissioning that any radioisotope other than uranium is a source of the surface contamination. The contaminated and suspected buildings were radiologically decontaminated during the period of August 1992 to May 1993. Each building was remediated and resurveyed to ensure that cleanup goals were met. Therefore, the description of radioactive contamination is no longer applicable. The extent of contamination observed during the Phase 2 RI is described here, but the description is not indicative of current conditions.

4.8.1 BACKGROUND RESULTS

Off-site background readings were taken at several locations, as indicated in Table 4-45. Most of the indoor readings were taken in brick buildings with concrete floors. Brick and concrete buildings were selected because this is the predominant construction used at MTL. The results are summarized in Table 4-46.

Eleven outdoor background FIDLER readings were taken at four off-site locations. The average of these off-site FIDLER readings was 5,273 counts per minute (cpm), with a standard deviation of 467 cpm. All of the off-site readings were taken on grass.

The average of all on-site background readings was 5,913 cpm. There was a significant difference in the reading depending on the material being surveyed. Table 4-47 gives the results of the survey for different materials. The average reading for grass is 5,424 cpm, which is comparable to off-site background readings. Readings for granite curbs and concrete walls were substantially higher, probably due to the presence of natural uranium.

4.8.2 OUTDOOR SURVEY RESULTS

The outdoor FIDLER survey results were correlated with the results obtained from surface soil samples analyzed for uranium. The FIDLER readings varied from 5,000 to 8,000 cpm, while the soil concentrations of uranium at the same locations varied from 1.0 to 4.3 pCi/g.



Figure 4-13 shows all locations with FIDLER readings of 9,000 cpm or more. Most of these locations have been attributed to concrete or granite surfaces. The area south of Building 39 is an asphalt parking lot. Since the outline of the elevated readings seems to have such a distinct shape, it seems likely that the asphalt that was used for this part of the parking lot had higher concentrations of natural uranium. Uranium is a common constituent of crude oil. The elevated readings may also be due to uranium containing minerals in the asphalt on-site.

There was only one spot that seemed to have the potential for contamination, which was located south of the reactor near the fence (labeled A in Figure 3-2). This spot had a FIDLER reading of 15,000 cpm. The interpretation of the outdoor FIDLER results indicates that, except possibly for this location, there is no apparent soil contamination caused by uranium from MTL operations.

4.8.3 SURFACE RADIOACTIVITY IN CONTAMINATED BUILDINGS

4.8.3.1 Building 43

The annex to the north side of the high-bay structure had no concrete floors, painted concrete block, and brick walls that were contaminated with radioactive materials. Beta-gamma activities exceeded 100,000 dpm/100 cm² on the floor. The painted wall surfaces in the annex were also contaminated to a lesser extent. The ceiling was not evaluated for radioactive contamination, but because of the activities performed in this room, it was assumed to be contaminated. The high-bay area of Building 43 consists of one large room with brick walls and a concrete floor. Widespread floor contamination, with some areas containing beta-gamma activity levels of over 100,000 dpm/100 cm², was found in this area. Because of this contamination, the pits beneath the heavy forging machines were also assumed to be contaminated.

An iron rafter beam over the incinerator in the southeast corner of the building had very high beta levels of approximately 4,000,000 dpm/100 cm², probably caused by uncontrolled DU fires in a former DU storage area that occurred in the past. Another reading taken on the rafters had only slightly elevated readings. The ceiling was not surveyed, but most of the roof was recently refurbished and replaced.

The lower portions of the painted brick walls did not appear to be contaminated, but elevated radiological activity levels from existing equipment precluded a complete assessment of contamination on the walls.

The floor around some of the machines was covered with a thick clay-like material that is believed to be a mixture of lubricating oil, absorbing clay, and DU. It was radioactive, thus warranting classification as a low-level radioactive waste. This material was as thick as 1 inch in places.

Three contaminated floor or shower drains were identified in Building 43. These drains discharged to the sanitary sewer line in Arsenal Street.



4.8.3.2 **Building 312**

The painted plaster surfaces in the DU machining rooms (Rooms 111 and 117 through 126) contained elevated levels at dark spots on the wall. There was more than one layer of paint, and it was not determined if the underlying layers were radiologically contaminated.

There is widespread contamination on the floor in the DU and beryllium machining rooms and the plating shop. Beta-gamma levels were as high as 1,000,000 dpm/100 cm². Although there were portions of this area that did not exceed background-level readings, the extent of contamination was widespread. There were more than 10 contaminated drains in the DU and beryllium machining areas. In addition, there was a contaminated shower drain on the third floor that is believed to have been used by persons performing maintenance on filter systems that were located on the third floor. These drains discharged to a sanitary waste line that flows south, hooks up with another facility line, and eventually discharges to a municipal line on Beacon Street.

Each machine in the DU and beryllium machining areas was connected to the vacuum exhaust system. The vacuum lines went to cyclone separators, filters, and blowers on the third floor and discharged through the roof. There were independent vacuum systems servicing the DU and beryllium areas separately. They had separate lines, cyclones, filters, and blowers. They connected after the blowers at the exhaust pipe. This system was not opened, but the entire system was believed to be contaminated because of the high level of contamination in the machining area. Each room had an air duct in the ceiling. The exhaust air went to a fan on the third floor and is discharged through the roof. This system was not opened and surveyed but was believed to be contaminated because of the activities in this area.

Contamination was also found at two other locations in Building 312. A drain and grate were found to be contaminated in Room 139, and a portion of the floor in Room 219 was contaminated with elevated levels of beta-gamma activity.

Some rooms have beta-gamma readings that were slightly above background levels but are below the NRC and Massachusetts surface activity limits. These rooms, called Category 3 rooms, are discussed in Subsection 4.8.6.

4.8.4 SURFACE RADIOACTIVITY IN SUSPECTED BUILDINGS

4.8.4.1 **Building 37**

Other than the isotope storage area located on the second floor (Risk Management Office) of this building, there was no evidence to indicate that Building 37 was used to house operations involving radioactive materials.

In general, Building 37 was not contaminated. Elevated readings were found near two open pipes and a manhole cover. General decontamination was recommended as



described in the FDP (WESTON, April 1992) and the Decommissioning and Decontamination Contractor Specifications (Stone and Webster, June 1992).

4.8.4.2 Building 39

The radiological investigation found contamination in five rooms. A cutoff pipe in Room 501 on the fifth floor exhibited elevated beta-gamma readings. The pipe chase had been cemented, and measurable radioactivity has been reduced although presumably not eliminated. In Room 512, one drain and sink along with two bench tops exhibited elevated beta-gamma readings. This area is the former location of an analytical chemistry laboratory. A fume hood countertop in Room 145 was used to polish DU metal samples and is contaminated. No elevated radiation levels were detected in the hood drain, exhaust vent, or at the ventilation discharge on the roof.

A small crevice in the floor tile on the second floor showed elevated radiation readings. This contamination is probably the result of a small spill.

Room 101A on the first floor has been identified as the former location of a DU melt room. It had a floor drain with elevated beta-gamma levels. This drain and other contaminated drains in the building discharge to the sanitary sewer lines under North Beacon Street.

At the time of the survey, DU was stored in Room 248. This area, along with Rooms 202 and 247, was believed to be the location of a DU machine shop during the 1950s. It was difficult to adequately survey these rooms because of interference from the DU storage area.

The survey also included the steam tunnels under the building and all exhaust vents on the roof. No elevated readings were found.

4.8.4.3 **Building 97**

No elevated radiation levels were found in the building; however, the former radiation waste sump and the drain to which the sump discharged are still located in the building. The maximum total alpha activity, and the maximum total beta-gamma activity was within the range of background readings. Removable alpha and beta activities were less than 1,000 dpm/100 cm².

4.8.4.4 **Building 241**

Building 291 was surveyed on September 19, 1992, after radioactive waste that had been stored in 241 at the time of the Phase 2 RI was removed. Elevated beta-gamma total activities were measured (maximum value 280,000 dpm/100cm²). The removable beta activity was well within the release limits.



4.8.4.5 **Building 292**

Two areas in this building were found to be contaminated by past activities involving radioactive materials. A sink drain in Room 244 was contaminated with elevated levels of total beta-gamma radioactivity. The drain discharges to a sanitary sewer that flows south to a manhole on the facility before eventually leaving the site. Elevated beta-gamma activity was also found in the north stairwell of the building. With the exception of these two contaminated areas, the building was generally not contaminated.

4.8.4.6 **Building 311**

The radiological investigation identified a contaminated sump at the east end of the building. This sump was connected to a trench drain and had an elevated total betagamma reading. There is no visible drain, but the bottom of the sump was covered with dirt. The effectiveness of the survey at these locations was reduced because of the radiation levels from the stored radioactive materials. Floor surfaces underneath storage boxes and waste drums may be contaminated but were not surveyed. The roof and rafters were also surveyed, and no contamination was found.

4.8.4.7 **Building 313**

No contamination was found in the building; however, radioactive contamination was present in a large cistern beneath the center wing of the building. The sediment in this cistern was found to contain from 40 to 50 pCi/g of uranium in two samples. It is not known how the cistern is connected to other piping systems or where the radioactive contamination originated. See Subsection 4.8.6 for a discussion of Category 3 rooms.

4.8.5 SURFACE RADIOACTIVITY IN NOT SUSPECTED BUILDINGS

No evidence has been found to indicate that the not suspected buildings were even used to house operations involving radioactive materials. These buildings (Buildings 36, 60, 111, 117, 118, 131, 229, 243, 246, and 656) were surveyed for release for unrestricted use. Each survey reading was compared with the surface activity limits of Subsection 4.1. In addition, following the recommendations of NUREG/CR-5849 "Manual for Conducting Radiological Surveys in Support of License Termination," the upper bound of the mean at the 95% confidence interval for each floor of each building was compared with the surface activity limits. This value is calculated by the following equation:

$$\mu = \text{mean} + t \frac{S_x}{\sqrt{n_s}}$$



Where:

 μ = Upper bound of the mean at 95% confidence interval.

mean = Mean of instrument readings for a floor of a building.

t = The 95% confidence level for $n_2 - 1$ degrees of freedom. This is a tabular value.

 $s_x = Standard deviation.$

 $n_s = Number of instrument readings.$

All survey points for total alpha and beta-gamma and removable alpha and beta were less than the values contained in Tables 4-3 and 4-4. The calculation of the upper bound of the mean for each floor for each building is presented in Table 4-48 and 4-49. Each value of μ is well within the guideline values.

4.8.6 MISCELLANEOUS SURVEYS RESULTS

4.8.6.1 Roof Survey Results

An informal survey of the roofs on Buildings 39, 43, and 311 was completed. For each of these buildings, random locations and areas around ventilation exhaust vents were checked with a pancake G-M detector. A systematic survey was not conducted because if contamination were to exist on the roof, it would most likely be evident around exhaust vents. No elevated readings were found during the roof surveys.

4.8.6.2 Steam Tunnels Survey Results

An informal survey was completed in all of the steam tunnels that interconnect some of the buildings. The tunnels were found to be clean and there was no visible evidence of spillage of materials from other buildings such as Building 43. As near as could be determined from a review of facility drawings and visible inspection of the steam tunnels, no sanitary sewer lines discharge into or flow through the steam tunnels. No elevated readings were found in the steam tunnels with a pancake G-M detector.

4.8.6.3 Hoods and Ventilation Systems Survey Results

A limited survey of the ductwork above hoods and other ventilation lines was completed. For a number of hoods that had elevated readings or were located in rooms with contamination, the exhaust duct above the hood was surveyed as far as could be reached with a pancake G-M detector. The hoods surveyed were in Rooms 512, 501, 331, and 137 in Building 39 and in Rooms 143 and 145 in Building 97.

The hoods and other ventilation systems in Building 39 exhausted onto the roof. Each exhaust vent and the roof around it was surveyed with a pancake G-M detector. No elevated readings were found.

The machinery ventilation system for the beryllium and DU machine shops in Building 312 flows through a HEPA system, which consists of two cyclone separators, a filter,



and a blower. The exhaust is filtered prior to discharge through a pipe that exits through the roof. The system was not surveyed, although it is assumed to be contaminated due to the elevated levels of contamination throughout this area of the building.

The ventilation systems in Building 43, one for the incinerator and one for the DU melter, were not surveyed. Both systems are assumed to be contaminated due to the elevated levels of contamination found in these areas.

4.8.6.4 <u>Drainlines Survey Results</u>

Because drains in Buildings 39, 43, 292, and 312 were found to have elevated radiation levels, it is possible that the piping systems into which the drains discharge are also contaminated. Since it was not possible to determine where the drains discharged based on a review of facility drawings, dye tests were done for all contaminated drains. Several manholes on the facility were opened. Most manholes on the facility have the sanitary sewage lines flowing through a trench in the bottom of the manhole. There is no difference in elevation between the inlet, the trench, and the outlet, so there is no place for sediment to collect. For some of the lines, the first sediment traps occur in the manholes on Arsenal or Beacon Street. A manhole on Arsenal Street downstream of Building 43 and a manhole on Beacon Street downstream of Building 39 were surveyed.

The manholes on Beacon and Arsenal Streets have inlet and outlet lines entering at a higher elevation than the bottom of the manhole, and consequently they have sediment in the bottom. Both manholes had elevated radiation levels, based on readings taken with a pancake G-M detector. The manhole on Arsenal Street had readings of 100 to 150 cpm on the bottom, while the one on Beacon Street had readings of 150 to 200 cpm. By comparison, the off-site background readings for the pancake G-M detector averaged 55 cpm.

4.8.6.5 Borehole Gamma Logging Results

A gamma detector was lowered into boreholes located inside Buildings 37, 43, and 311 and at the southwest corner of the installation powerplant. The detector was lowered into the borehole before the casing was installed or the hole filled in. The results of the radiation logging are presented in Table 4-51. There is no indication of contamination in the boreholes that were logged.

4.8.7 BUILDING REMEDIAL ACTION AND RISKS

Radiological contamination was remediated under the authority of the NRC during the period of August 1992 to May 1993. Facility decommissioning and verification surveys are required before the NRC will allow the facility to terminate its licenses to possess radioactive materials and allow unrestricted use. The decommissioning activities consist of three major categories of activities:



- The most heavily contaminated areas received an extensive decontamination of all the surfaces and equipment. This effort included removal of a substantial amount of equipment that was either cleaned or disposed of as low-level radioactive waste. Contaminated surfaces were cleared or the surface layer was removed. Drainlines were tested for contamination and removed. This extensive decontamination effort was performed for all of Building 43 and the following areas of Building 312: the beryllium and DU machine shops, the plating shop, and the DU and ventilation system on the third floor.
- Spot decontamination was performed in other areas where elevated levels of radioactivity were found in isolated areas. Typically, these areas are a laboratory sink, a hood bench top, floor drains, sumps, and small isolated contaminated areas, generally less than 1 ft² in area. These areas were cleaned or removed as necessary. These isolated areas existed in Buildings 37, 39, 97, 292, 311, and 312.
- Certain areas (identified as Category 3 in the FDP) had slightly elevated radiation levels compared to background but still less than the surface activity limits presented in Subsection 4.1. These areas are identified on Table 4-52. These areas were resurveyed during decommissioning to determine if janitorial cleaning was required.

These decommissioning activities reduced the potential for radiological exposure from contamination at MTL to well below the exposure from natural sources. The surface activity limits in Table 4-4 were established to comply with the Commonwealth of Massachusetts request that the annual dose to future occupants of these buildings be limited to 10 mrem/yr. By comparison, the average annual dose to individuals in the U.S. is about 100 mrem/yr. It should be emphasized that the cleanup activities should reduce the future dose to well below 10 mrem/yr because the FDP specifies that the decontamination activities result in surface activities that are not just below the limits but are as low as reasonably achievable. This means that the decommissioning contractor will continue to decontaminate surfaces as long as reasonable decontamination methods result in a reduction of contamination levels.

4.9 INDOOR SURFACE CHEMICAL SAMPLING RESULTS

The indoor surface chemical data are presented in Appendix J. These results were compared to the calculated guidelines for indoor surfaces (see Subsection 4.1). Table 4-53 summarizes the rooms in which chemicals were found at concentrations exceeding the calculated guidelines. Only those chemicals for which guidelines could be calculated are discussed in the following subsections. Rooms containing such chemicals may require remediation of indoor surfaces. The appropriate guidelines are presented in Table 4-6.



4.9.1 BACKGROUND SAMPLE RESULTS

A total of 6 organic and 16 inorganic contaminants were detected in one or more of the eight background indoor surface samples.

4.9.2 BUILDING 111

Wipe samples from these rooms (0.1, 2.1, and 3.1) in Building 111 contained concentrations of analytes exceeding the calculated guidelines.

4.9.3 BUILDING 117

Lindane was found in Room 1 of Building 117 at a concentration exceeding the calculated guideline; however, the lindane detection was considered unconfirmed by the lab.

4.9.4 BUILDING 118

Lindane concentrations in Room 0.1 were found to exceed the calculated guideline.

4.9.5 BUILDING 131

Room 2 contained concentrations of lindane, dieldrin, and zinc that exceeded the calculated guidelines, as did in Rooms 3 and 39 for lindane; however, the lindane and dieldrin detections were considered unconfirmed by the lab.

4.9.6 BUILDING 243

Rooms 1, 2, 3, and 4 each contained concentrations of various analytes exceeding the calculated guidelines. Room 2 had the most exceedances (six), including PCBs, dieldrin, and zinc.

4.9.7 BUILDING 292

Rooms 133, 134, 125, 128, 106, 132, 244, 245, and 250 contained concentrations of various analytes exceeding the calculated guidelines, with Room 132 having the most exceedances. Typical contaminants included PCBs, PAHs, and metals.

4.9.8 BUILDING 311

Concentrations of various analytes exceeded calculated guidelines in 33 rooms/sampling areas in Building 311. These results are to be expected, considering the large number of machining and laboratory activities ongoing in the building. A wide variety of analytes (primarily metals) were detected on interior surfaces, which is reasonable considering the wide variety of industrial activities in the building.



4.9.9 BUILDING 312

Concentrations of various analytes (primarily metals, with some PAHs and PCBs) exceeded calculated guidelines in 24 sampling areas in Building 312. These detections are to be expected, given the industrial and research use of the building during its history.

4.9.10 BUILDING 313

Concentrations of various analytes (primarily metals, with some explosives and PAHs) exceeded calculated guidelines. Past use of explosives in the building would account for the detection of 2,4-DNT in Rooms 0.5, 0.6, 0.7, and 0.8.

4.9.11 BUILDING 36

Concentrations of various analytes (primarily metals and PCBs) exceeded calculated guidelines in the auditorium, the basement, and Room 102. In the auditorium, only zinc exceeded the guideline (which is 0).

4.9.12 BUILDING 37

Concentrations of various analytes (primarily metals, with some pesticides, PCBs, and PAHs) exceeded calculated guidelines in 18 sampling areas in Building 37.

4.9.13 BUILDING 39

Due to the size and previous uses of Building 39, a total of 52 rooms contained analytes at concentrations exceeding the calculated guidelines. The contaminants were primarily metals, with some BNAs. The chemical agent byproduct di-isopropylmethylphosphonate (DIMP) was detected in one wipe sample from Room 531.

4.9.14 BUILDING 43

Concentrations of several analytes in the storage room and the DU cage of Building 43 exceeded the calculated guidelines. Concentrations of arsenic, copper, and zinc exceeded the guidelines in the storage room, and concentrations of arsenic exceeded the guideline in the DU cage.

4.9.15 BUNKERS

2,4-DNT was detected in the right bunker at a concentration exceeding the calculated guidelines. No other analytes were detected in the bunkers.



4.10 AIR SAMPLING RESULTS

Samplers (equipment) were rotated through each building. Samplers were placed in locations in which access was available and exhibited the greatest potential of contamination. These locations were determined during a pretest walk-through by the air sampling team. Figure 4-14 depicts these locations.

4.10.1 QA AND BACKGROUND RESULTS

No significant contamination was noted in any of the QA samples, with the exception of the metals samples, which contained high concentrations of aluminum, barium, calcium, chromium, magnesium, and potassium. This resulted in the inability to distinguish between compounds in the air and contamination in the sample container. This type of interference between sample container and the air sample is common in samples of specific metals, such as those found in the blank metals samples, can mask concentrations of those metals in the ambient air sample. The concentration in the sample was attributed to blank contamination rather than site contamination if the concentration in the sample was less than two times the blank concentration.

4.10.1.1 On-Site, Phase 2 Background Results

During Phase 2, a total of 51 background samples were collected from various outdoor areas throughout the facility. Appendix I.2 contains lists of these samples, their dates of collection, and their analyses. Three samples (BG-AIR3-1, BG-AIR3-5, and BG-AIR3-6) were analyzed for TAL metals. Of the 23 metals analyzed, only one was not detected (beryllium). The remaining two samples (BG-AIR3-4 and BG-AIR2-8) were analyzed for cyanide only. None was detected.

Uranium isotopes U-234, U-235, and U-238 were detected at very low concentrations (each less than 7.5 x 10⁻⁴ pCi/m³). In addition, U-234 and U-238 were detected in the method blank for three samples analyzed (BG-AIR3-1, BG-AIR3-5, BG-AIR3-6). In all three samples, the ratio of U-234 to U-238 was approximately 1:1 (considering orders of magnitude). This is indicative of natural uranium, which one expects to find in an outdoor ambient background sample. The presence of natural uranium and its daughter products would also explain why the gross alpha activity is not fully accounted for by the presence of U-234, U-235, and U-238.

Seventeen VOCs were detected in one or more of the three background samples analyzed for VOC compounds. Seven PAH compounds were detected in one or more of three samples analyzed. None of the PCB aroclors was detected in either of the two background air samples analyzed. No explosives were found in any of the three background air samples analyzed. Low levels of nitrates were detected in two of the three samples analyzed (BG-AIR3-1 and BG-AIR3-6). Since explosives were not detected, it can be assumed that the nitrates are not an explosives indicator but come from some other source, such as fertilizers. Sample results from each building (Table 4-54) will be compared to ARARs (see Subsection 4.1).



4.10.1.2 Regional Background Information

During 1989, air toxics data were collected from three stations in the greater Boston metropolitan area. These stations were located as follows:

- The roof of the Kenmore Square (Boston) air monitoring station at a height of 15 ft aboveground on a traffic island in a busy intersection.
- The roof of the Social Center in Charlestown City Square (Boston). This station was located 50 ft aboveground in a mixed residential/commercial area within ½ mile of the I-93/Route 1 intersection.
- At the Sudbury air monitoring station in a field of the Great Meadows Wildlife Refuge, 12 ft aboveground.

Twenty-four-hour samples were collected and analyzed for VOCs. A report was published (MADEP, 1990) which summarizes the data quarterly and annually. The report presents results for the seven most commonly detected compounds for both high-and low-flow sample collection scenarios. The report also presents data for the three most frequently detected compounds. The most frequently detected compounds were TCA, benzene, TCE, toluene, ethylbenzene, xylene, and PCE. This is to be expected, since many of these compounds are associated with automobile fuel and with many industrial processes.

During 1990, the same air sampling strategy was followed, except that two additional locations were sampled. These were:

- Thirty-five ft aboveground, on the roof of a YMCA building 1 km from the center of the city of New Bedford, MA, in a commercial area.
- Forty-five ft aboveground on the roof of the Southampton Bay (Boston) Fire Station, ½ mile from Highway I-93.

Results from 1990 sampling were reported as being virtually the same as those from 1989 in those instances where the sampling locations for each event coincided. Therefore, comparisons of MTL data need only be made with the 1990 sampling data. Furthermore, only the fourth quarter MADEP data will be compared to MTL data, since these include the month of November, which is when MTL was sampled. In addition, since MTL data were collected at heights of approximately 6 ft (the breathing zone), comparisons will be made only with the lower altitude MADEP data. Finally, comparison to Sudbury data will not be done, since the Sudbury location is in a wildlife refuge, while MTL is in an industrialized area. For the reasons outlined above, MTL air data were compared with MADEP data from the New Bedford and Kenmore Square sampling locations in Subsections 4.10.2 through 4.10.14.



4.10.2 BUILDING 36

None of the analytical results for metals exceeded either occupational or public health standards. Of the VOCs analyzed, 15 were found at concentrations above the detection limit. Of these VOCs, none was present at concentrations exceeding either occupational or public health standards. None of the detected VOCs was above MADEP regional background data.

No explosives were detected in the air sample from Building 36. Nitrates were found at just below $1 \mu g/m^3$. No air standards exist for nitrates.

4.10.3 BUILDING 37

During normal building operations, both gasoline- and diesel-powered vehicles pulled in and out of the adjacent work bay. This would result in a positive bias of VOCs.

Particulates were detected at concentrations below public health standards.

Thirteen VOCs were detected. Benzene, ethyl benzene, toluene, and xylene were detected, indicative of the fact that Building 37 houses the motor pool area and vehicles are often idling within the building. The following VOCs were above MADEP regional background data: ethylbenzene, PCE, toluene, and xylenes. None of the detected volatile compounds was present at concentrations exceeding the current occupational health standards or public health guidelines.

No SVOCs were detected.

4.10.4 BUILDING 39

None of the 20 metals detected (of those for which such standards exist) were present at levels exceeding public health standards. For metals with no corresponding public health standards, none were present at levels greater than the current occupational health limits.

Radiological results for the uranium isotopes of interest reveal that the uranium levels were five to six orders of magnitude below the enforceable NRC limits set by 10 CFR 20. Gross alpha activities ranged from 0.13 to 0.32 pCi/m³, while beta activities were between 0.45 pCi/m³ and 0.55 pCi/m³.

Seventeen VOCs were detected in the three samples collected in Building 39. Three of the VOCs detected (ethylbenzene, TCA, and xylenes) were above MADEP regional background data. Of these, none exceeded public health or occupational health levels.

Nine semivolatile compounds were detected. Of these, neither exceeded occupational health standards. No public health standards were available for the compounds detected.



No explosives were found in any of the three samples from Building 39. Nitrates were detected at concentrations ranging from $2.64 \,\mu\text{g/m}^3$ to $7.6 \,\mu\text{g/m}^3$. Currently, there are no health standards for nitrates in air.

4.10.5 BUILDING 43

The removal of equipment involved in the processing of DU in this building could have caused a positive bias for radioactive samples collected. Prior to commencement of other RI field activities, three air samples were collected and analyzed for beryllium and radiological parameters in Building 43. This was done to ensure personnel safety during fieldwork. Beryllium was not detected in any of the samples. Radiological parameters were well below levels set by the NRC in 10 CFR 20.

None of the 20 metals detected in Building 43 exceeded occupational health standards. Additionally, the metals found were present at concentrations at least one order of magnitude below current public health standards.

Enforceable standards (10 CFR 20) for U-234, U-235, and U-238 were not exceeded in any of the three samples analyzed. In two of the samples (43-AIR1-3 and 43-AIR2-3), the U-238 concentration exceeds the U-234 and U-235 levels by one to two orders of magnitude, indicating the presence of DU; however, the gross alpha activity exceeds the total uranium activity by one order of magnitude in 43-AIR2-3 and by two orders of magnitude in 43-AIR1-3, indicating that other alpha-emitting isotopes besides uranium (such as the uranium and thorium daughters) must be contributing. Such a scenario would be true of natural uranium. Therefore, it can be speculated that both the natural and depleted forms of uranium are present at levels below standards in the air of Building 43.

Eighteen VOCs were detected in one or more of the three air samples collected in Building 43 (43-AIR1-3, 43-AIR2-3, and 43-AIR3-3). Six detected VOCs (benzene, ethylbenzene, PCE, toluene, TCA, and xylenes) exceeded MADEP regional background data. As expected, none of the VOC levels detected exceeded occupational exposure limits. In addition, public health standards (for those few compounds for which such standards exist) were not exceeded. All such compounds were found at levels at least one order of magnitude below WHO or ASHRAE standards.

Eight PAH semivolatile compounds were detected in the three samples (43-AIR1-3, 43-AIR2-3, and 43-AIR3-3) collected in Building 43. For those detected compounds with associated occupational health standards (naphthalene only in this case), none of the standards was exceeded. No public health standards currently exist for the PAH compounds.

PCB Aroclor 1242 was detected in all three Building 43 samples analyzed (43-AIR1-3, 43-AIR2-3, and 43-AIR3-3). All results were less than $0.2\,\mu\text{g/m}^3$. This is well below any of the ACGIH TLVs for PCBs. Aroclor 1242 was not detected in any of the background samples.



4.10.6 BUILDING 60

Sixteen VOCs were detected in the sample collected from Building 60 (60-AIR3-8). The detected VOC levels were far below OSHA, NIOSH, and ACGIH occupational health standards. These levels were also below current WHO and ASHRAE public health standards. Detected VOCs did not exceed MADEP regional background data. In sample 60-AIR-3-8, 7 of 17 PAH compounds analyzed were detected. All of the PAHs found were present at levels far below occupational health standards. No public health standards exist for these compounds.

4.10.7 BUILDING 97

During sampling, work was being performed in Room 145 that involved the removal of lead bricks.

Of the metals detected in Building 97, none was present at levels exceeding occupational or public health standards.

Radiological samples 97-AIR2-2 and 97-AIR3-3 contained detectable U-234, U-235, and U-238 concentrations that were below the corresponding enforceable limits in 10 CFR 20. The fact that U-238 is present at nearly twice the concentration of U-234 in 97-AIR3-2 indicated that some of the uranium may be depleted uranium; however, much more gross alpha activity is present (on the order of 0.1 pCi/m³) than could be accounted for by the uranium isotopes alone. This suggests the possible presence of natural uranium and thorium and their daughters.

All of the 16 VOCs analyzed were present in one or both of the samples from Building 97. Only PCE exceeded MADEP regional background data.

Only seven PAHs were detected. No PAH in Building 97 was present at levels exceeding ACGIH, NIOSH, or OSHA occupational health standards.

PCB Aroclors 1242 and 1254 were detected in both PUF samples collected in Building 97. Neither was present at levels exceeding the ACGIH TLV for chlorodiphenyls.

4.10.8 BUILDING 131

None of the metals concentrations exceeded WHO and/or ASHRAE public health standards.

Sixteen VOCs were detected in 131-AIR2-9. Three detected VOCs (PCE, TCA, and xylenes) exceeded MADEP regional background data. In addition, no VOC samples exceeded occupational health standards or public health guidelines.



Seven PAH compounds were present at detectable concentrations. No PAH levels exceeded ACGIH, OSHA, or NIOSH standards. No public health guidelines currently exist for PAHs.

4.10.9 BUILDING 241

Building 241, the radiological materials storage shed, was sampled for radiological activity only. Detectable gross alpha, gross beta, and uranium activities were noted. Of the three uranium isotopes analyzed, only two, U-234 and U-238, were detected. The U-234:U-238 ratio is exactly 1:1, indicating the presence of natural uranium in the building. In addition, gross alpha and beta activities exceeded $0.1~\rm pCi/m^3$, whereas only $1.36~\rm x~10^{-3}~\rm pCi/m^3$ of activity can be accounted for by the presence of the uranium isotopes. This suggests the presence of natural uranium daughter products. These facts lead to the conclusion that only natural uranium raw materials, and not DU, were stored in Building 241. The levels of uranium activity are below the enforceable uranium limits published in 10 CFR 20. The gross alpha and beta radioactivity is also less than that allowed for uranium by 10 CFR 20.

4.10.10 BUILDING 243

No metals concentrations exceeded ACGIH, OSHA, or NIOSH occupational health standards. In addition, for those few metals for which public health guidelines exist, none was exceeded.

Sixteen VOCs were present at levels above the detection limit in sample 243-AIR2-7. MADEP regional background levels were exceeded for three VOCs (benzene, toluene, and TCE). No VOC concentrations exceeded occupational health standards, with detected levels at least three orders of magnitude below the most conservative standard. In addition, for those VOCs for which public health standards exist, none was exceeded.

Five PAH compounds were detected in sample 243-AIR2-7. None exceeded occupational health standards, and no public health standards for PAHs exist.

Cyanide was not detected in sample 243-AIR1-8.

4.10.11 BUILDING 292

Samples were taken over two consecutive nights due to the lack of available power outlets during working hours. The lack of activity during nonworking hours could result in a negative bias in all samples.

Sixteen of the 23 metals analyzed were detected in one or both of the samples collected in Building 292. Occupational health standards and public health guidance were not exceeded for any of the metals detected in either of the two samples.



Isotopic uranium activities for U-234 and U-238 were detected in two samples from Building 292. In one sample (292-AIR2-8), U-238 activity was an order of magnitude higher than the U-234 activity, indicating the presence of DU; however, in the second sample, 292-AIR2-8, there was more U-234 activity, with each isotope present at levels on the order of 10⁻⁴ pCi/M³, indicating that this sample contains primary natural uranium. Sample 292-AIR1-8 was collected in Room 128, a laboratory, whereas 292-AIR2-8 was collected in Room 117, a mechanical/storage room. It is possible that DU was handled in Room 128, which would explain the results. All isotopic uranium results were below the enforceable standards published in 10 CFR 20.

Seventeen VOCs were detected in one or both of the air samples collected in Building 292. Degreasers and other cleaning agents may be a source of VOCs in 292-AIR1-8. Two detected VOCs (ethylbenzene and xylenes) exceeded MADEP regional background data. Additionally, no occupational health standards or public health guidelines were exceeded.

Four PAHs were detected in one or both of the air samples from Building 292. No PAHs were present at levels exceeding occupational health standards (for those PAHs for which standards exist).

No explosives or nitrates were detected in either of the two air samples collected in Building 292.

4.10.12 BUILDING 311

Sampling was conducted on 12 November 1991, a federal holiday, when no activities were being conducted. Drilling operations inside the building had occurred and concluded during the days prior to sampling. This could result in a positive bias in sample results.

Fifteen metals were detected, but none exceeded occupational health standards.

U-234 and U-238 were detected in all three samples. In 311-AIR1-1 and 311-AIR2-1, U-238 concentrations exceed those of U-234. In 311-AIR1-2, however, U-234 exceeds U-238. This indicates that 311-AIR1-1 and 311-AIR2-1 contain primarily DU and that the uranium in 311-AIR2-1 consists primarily of natural uranium. The fact that the gross alpha/gross beta activities are three to four orders of magnitude higher than the U-234, U-235, and U-238 activities suggests the presence of other radioactive isotopes, such as may be found in natural uranium.

Eighteen VOCs were detected in one or more of the three air samples in Building 311. Only one detected VOC (PCE) exceeded MADEP regional background data. No occupational health standards or public health guidelines were exceeded.

Seven PAHs were detected in one or more of the three samples collected. No health standards or guidelines were exceeded.



PCB Aroclors 1242 and 1254 were detected in samples 311-AIR2-1 and 311-AIR1-2. Background tolerance levels were exceeded; however, the ACGIH TLV for chlorodiphenyls was not exceeded. The presence of transformers that have contained PCBs in the past could explain the presence of PCBs in the air of Building 311.

Nitrates were detected in 311-AIR2-1. Because no explosives were detected, it is unlikely that these nitrates are present as an explosives indicator. It is more likely that the nitrates are associated with some of the machining processes in the building.

Explosives and cyanide were not detected.

4.10.13 BUILDING 312

The metals results collected from sample 312-AIR-4 were not representative of other metals samples taken in the same building. Although the sampler did not appear to have operational problems, the final results for total particulate and metals were an order of magnitude lower then for the other samples from that building. Other types of samples taken at this same location during the same time frame did not exhibit the same result when compared to the other sample locations in the same building. The results exhibited by the metals PM-10 sampler would indicate that the sampler was not operational for the entire sampling period, resulting in an unknown reduced sample volume that negatively biased the final sample results. Therefore, the metals results from 312-AIR1-4 will not be considered in this RI.

Detected metals included cadmium, nickel, and zinc, which are associated with plating operations that were conducted in the building. Beryllium was not detected in either sample, suggesting that the beryllium machining conducted in 312 has had little effect on the air outside of the machine shops.

U-234 is present at levels slightly lower but of the same order of magnitude as U-238 in all samples (312-AIR1-4, 312-AIR2-4, and 312-AIR3-4). In addition, gross alpha and beta activities are present at levels two to four times greater in order of magnitude than the uranium isotopic activities. These data, taken together with the fact that Building 312 has been used in part for DU machining, indicate that both DU and natural uranium may be present in the air samples from Building 312. In no samples were the enforceable 10 CFR 20 levels for isotopic uranium exceeded.

In addition to 312-AIR1-4, 312-AIR2-4, and 312-AIR3-4, three air samples were collected and analyzed for beryllium prior to commencement of other sampling activities for personnel safety monitoring. Concurrently, three air samples were collected and analyzed for radiological parameters. Radiological samples were collected using a high-volume TSP sampler. Samples analyzed for beryllium were collected with a similar apparatus fitted with a special filter inlet head. None of the samples analyzed for beryllium contained detectable concentrations. Samples analyzed for U-234, U-235, and U-238 were below the appropriate NRC (10 CFR 20) guidelines. Generally, gross alpha and gross beta levels were not present at elevated levels compared to other site air



samples, except in one former spill area (the sample was taken approximately 6 inches above the floor where the spill occurred). Other samples contained much lower readings.

Fifteen VOC compounds were detected in one or more of the three air samples collected in Building 312. Concentrations of 2-butanone, 1,4-dichlorobenzene, trichlorofluoromethane, and xylenes exceeded those found in site background samples, although the levels were still less than twice the background concentrations. Two detected VOCs (ethylbenzene and PCE) exceeded MADEP regional background data. In addition, no occupational health or public health limits (where available) were exceeded.

Cyanides were not detected in any of the three samples collected.

4.10.14 BUILDING 313

Three samples (313-AIR1-5, 313-AIR2-5, and 313-AIR3-9) were collected in Building 313. A vessel containing PCBs was being remediated in this building the day before sampling operations took place. The work area was cordoned off so that no work activity was conducted while sampling was in progress. PCB analysis was added for one of the air samples. Because of the remediation activity, the PCB sample results may have a positive bias.

Of the 23 metals analyzed, 19 were detected in one or more of the three air samples collected. No occupational or public health limits were exceeded.

The ratio of U-234 to U-235 in the samples ranges from approximately 1.2:1 to 1.5:1, indicating that the uranium present is not depleted. This is supported by the high gross alpha levels (at a 10⁻¹ pCi/m³ order of magnitude) relative to the levels of uranium found. This indicates the presence of other alpha emitters, such as might be found in natural uranium. None of the enforceable 10 CFR 20 limits was exceeded in any sample.

Sixteen VOCs were detected in one or more of the air samples collected. Of those detected, acetone, styrene, toluene, 4-methyl-2-pentanone, dichloromethane, 1,4-dichlorobenzene, and TCA exceeded background values; however, all levels were comparable to background. Only two VOCs (toluene and TCA) exceeded MADEP regional background data. No health standards were exceeded.

Ten PAH compounds were detected in one or more of the three samples from Building 313. Most of the detected compounds slightly exceeded background. None of the existing occupational or public health limits was exceeded.

One PCB, Aroclor 1254, was detected in the only air sample analyzed for PCBs. The presence of this compound is likely due to the remediation of a PCB-containing vessel in the area, as described above. Occupational health standards published by ACGIH were not exceeded.



Explosives were not detected in any of the three samples analyzed.

Nitrates were present at detectable levels in all three samples analyzed. Levels were approximately twice the background level. No health standards for nitrates exist. Since no explosives were found, it cannot be said for certain that nitrates are present as an explosives indicator, although extensive ballistics work is conducted in this building.

4.10.15 **SUMMARY**

The numbers show very clearly that in general, contamination produced at MTL has not become airborne. As indicated in the text, under current conditions, no occupational or public health guidelines have been exceeded for any of the detected compounds/analytes. Therefore, for the majority of compounds analyzed, exposure via inhalation is not of concern under present site conditions. Should activities occur which may suspend or resuspend particulate matter (such as construction, demolition, etc.), caution should be exercised to reduce worker exposure.

4.11 CONTAINER SAMPLING RESULTS

The results of the investigation of cisterns, tanks, sumps, catch basins, and dry wells are presented below. Figure 4-15 depicts the container sampling locations. Appropriate background samples for chemical analysis were not available for comparison with container chemical sampling results, since no cisterns, tanks, sumps, or dry wells that were not influenced by industrial activities could be found in the area. Therefore, chemical results are itemized and discussed as they relate to site processes (where appropriate) without comparison to background.

For isotopic comparisons, an average value for the total uranium activity typically found in surface water was taken from the literature as 1 pCi/L (Richmond, 1988). For the container sediments, comparison to a soil cleanup level of 35 pCi/g was used (WESTON, 1992).

Appendix G contains field log forms detailing the physical characteristics of the containers sampled. Appendix M provides photographs of many of the containers. The results are discussed on a container-by-container basis below.

4.11.1 INDOOR CONTAINERS

The 15 indoor containers sampled include the following:

- A sump in Building 39
- Two sumps and a tank in Building 43
- A sump in Building 97
- Two sumps in the reactor building
- Three sumps and two tanks in Building 311



- A tank in the plating shop of Building 312
- A dry well in the basement of Building 313N
- A large cistern beneath Building 313C

The results of the container sampling, both water and sediment, are presented in Table 4-55.

4.11.1.1 Building 39

The sump in Building 39 is located in a tunnel beneath the southern portion of the building. The tunnel runs east-west and does not extend beyond the building boundaries. The sump contains a small pump and associated piping in a square hole measuring 3 ft on a side and 2 ft deep. A small, 2-ft² area on one side of the hole contained water but no sediment. Water collected from this area (39SW01) showed no semivolatile or pesticide contaminants at concentrations above 1 μ g/L (see Table 4-56). Methylene chloride, a common laboratory contaminant, was detected at 29.3 μ g/L. PCB Aroclor 1260 was detected at 2.04 μ g/L. It is possible that the PCB transformer in Building 39 is hydraulically connected to this sump.

Gross alpha and gross beta readings were 20 pCi/L and 50 pCi/L, respectively. When compared with readings from other containers across the site, these values number among the highest. Uranium concentrations were measured as follows: U-234 at 0.7 pCi/L, U-235 at 0.1 pCi/L, and U-238 at 6.4 pCi/L. The high ratio of U-238 to U-234 in the sample indicates the presence of DU. Additionally, the 1 pCi/L typical value for natural uranium is exceeded by 7.5 times. The origin of these radiological contaminants is unknown; however, DU experimentation and/or storage is known to have occurred in at least two rooms in Building 39. Several radioactive floor drains were found to be radioactive via instrument surveys. One or several of these drains may be hydraulically connected to the sump in question, and this could explain the radioactivity detected. In addition, potassium was detected at 8,670 μ g/L in the sump, and this could have contributed some natural beta-emitting radiation.

4.11.1.2 **Building 43**

Two tanks and one sump inside Building 43 were sampled. From the sump in the southwest corner of the building, one sediment (43SED01) sample and one liquid (43SW02) sample were collected. No organic contaminants were found in 43SED01 at concentrations greater than 1 μ g/g. Several inorganic contaminants, including six of the eight RCRA metals and cobalt, were detected at concentrations greater than 1 μ g/g. Of these, lead was found at the highest concentration (over 5,000 μ g/g). The origin of this lead contamination is not known; however, lead in the sump walls or in the associated piping is a possible explanation. Lead-containing materials may also have figured prominently in forging operations in the building. Nonzero concentrations were reported for each of the three uranium isotopes analyzed. Of the three uranium isotopes, U-238 was found at the highest activity (2.5 pCi/g); however, this does not exceed the soil action level of 35 pCi/g. This is unexpected since Building 43 has



historically been used for DU melting and forging. Sample 43SED01 also contained 576 $\mu g/g$ of potassium, a natural beta emitter.

The highest concentration of an organic detected in the water sample (43SW02) was of PCB Aroclor 1260 (1.25 μ g/g), which could be due to the presence of a transformer in Building 43. The transformer may have leaked PCB-containing oils onto the floor of the building, which then migrated to the sump. Another possibility is that PCBs may have been used as additives to lubricating oils used in Building 43 machinery in the past. The activity of U-238 (1.7 pCi/L) exceeded the average of 1 pCi/L. U-234 (0.8 pCi/L) was present at an activity slightly below this level. The ratio of U-238 to U-234 indicates that the isotopic uranium present is likely to have been produced during the DU forging operations conducted in Building 43.

A liquid sample (43SW03) was collected from a rectangular compartment beneath the 2,000-ton press in the east end of Building 43. The sample medium was essentially oil.

The sample contained detectable concentrations of three of the eight RCRA metals: cadmium, barium, and lead. These were detected at $44~\mu g/g$, $378~\mu g/g$, and $10.9~\mu g/g$, respectively. (Note: the chemical analytical results for these samples are reported in $\mu g/g$ because of the oily nature of the sample. Essentially, the sample was analyzed using the same laboratory method used for soils.) No organics were detected in the sample. Since the sample was detected beneath a press used for machining of DU and other metals, it is not unusual that metals were detected in the oil sample.

Radiological results for 43SW03 indicated gross alpha/gross beta activities of approximately six times the next-highest activities noted in any other container. Non-zero uranium concentrations were determined for all three isotopes analyzed. These results are indicative of the historical use of this press to process DU.

A sediment sample (43SED02) was obtained from a large in-ground tank beside the Acme "nut-and-bolt" machine along the south wall of Building 43. The tank is a rectangular concrete structure approximately 4 ft by 3 ft by 2 ft deep. No volatile or BNA extractable semivolatiles were detected. In addition, six pesticide compounds were detected at concentrations of less than 1 μ g/g. A number of inorganics, including five of the eight RCRA metals and cobalt, were detected. Of these, barium was detected at the highest concentration (469 μ g/g), followed by lead (301 μ g/g). The presence of these inorganics may be due to machining or alloying of other metals along with uranium. The proximity of a large "nut-and-bolt" machine to this tank supports this hypothesis. The detection of U-235 and U-238 in this area was not unexpected, given the DU forging and machining operations conducted within the building.

4.11.1.3 Building 97

A water sample (97SW01) was collected from a small sump in the southern end of Building 97. Two volatile organics, acetone and chloroform, were detected at concentrations of greater than 1 μ g/L. Chloroform is a common laboratory



contaminant, and it was not found in the duplicate sample collected at the sump. Therefore, its presence in the sump water is doubtful. Acetone, although a common lab contaminant, was found in the duplicate, suggesting that this result more likely indicates the actual sump contents. No BNAs or pesticide/PCB compounds were detected at concentrations of greater than 1 μ g/L. Of the eight RCRA metals, only barium (14.2 μ g/L) was detected. Although the sump is associated with cooling water for the reactor and with the reactor personnel decontamination showers, gross alpha and gross beta readings were both relatively low (less than 5 pCi/L). In addition, thorium and cesium were found at concentrations of less than 1 pCi/L.

4.11.1.4 **Building 100**

Two small tanks in the basement of the reactor building were examined. A water sample was collected from each (100SW01 and 100SW02-W). In addition, there was an oily layer in the sump from which 100SW02-W was collected. This layer was also sampled (100SW02-oily layer). Methylene chloride was the only volatile organic detected in 100SW01. Methylene chloride, however, is a common laboratory contaminant. Seven of the eight RCRA metals were detected, as were beryllium and cobalt. Six pesticides were detected.

The water sample 100SW02-W contained four of the eight RCRA metals. The detected concentrations ranged from 1.91 μ g/L (mercury) to 738 μ g/L (lead). In addition, four pesticides and five volatile organics were detected. Among these volatiles were acetone and methylene chloride. Both are common laboratory contaminants. The other compounds are likely to be associated with the oil layer in the sump, although the purpose of this oil is unknown. The highest pesticide concentration was for aldrin (0.165 μ g/L). It is likely that pesticides were applied in this area, as it is the basement of the reactor.

The oil layer sample (100SW02-oily layer) was analyzed for gross alpha and gross beta and was found to contain substantial amounts of each (42 and 310 pCi/L, respectively). The water beneath the layer (100SW02-W) contained high beta activity (4,000 pCi/L) relative to other cisterns, tanks, and sumps on the facility. In addition, total uranium exceeded 1 pCi/L in both water samples, with U-238 (in 100SW02-W) having the highest activity of 37 pCi/L. Since the sumps are located in the base of the reactor building, the radioactivity noted is not unexpected. The high activity of U-238 in both sump water samples indicates the presence of DU (as opposed to naturally occurring uranium); however, from the high alpha and beta activities, it is clear that other isotopes are also present, which is expected, since the sample was collected within the nuclear reactor building.

4.11.1.5 Building 311

Four sumps and two tanks inside Building 311 were sampled. Water samples were collected from three of the sumps and from one of the tanks. Sediment samples were collected from the second tank and the fourth sump. For the liquid samples from



Building 311, the only volatiles detected were acetone and methylene chloride (except in the case of 311SW03, where 1,1-dichloroethane (6.775 μ g/L), chloroform (12 μ g/L), and TCA (3.43 μ g/L) were also detected). These are common laboratory contaminants. No BNAs were detected in any of the indoor sump water samples from Building 311. No pesticides or PCBs were detected at concentrations of greater than 1 μ g/L in Building 311 sump water, except in 311SW02, where Aroclor 1260 was found at 1.31 μ g/L. This may be due to the presence of two transformer cages in the building.

Water sample 311SW02 was collected from a sump in the southwest portion of the building (at the southern wall) that is located approximately 25 ft below the floor surface. The only RCRA metal found in 311SW02 was barium (16.2 μ g/L). Neither cobalt nor beryllium was detected. Considering that this sump is located immediately adjacent to a large machine shop, the pooled water in the sump is relatively uncontaminated.

Low levels (<10 pCi/L) of alpha and beta radioactivity were detected, but isotopic scans did not detect any uranium. These isotopic results are lower than anticipated considering the proximity of 311SW02 to the DU storage area. The gross beta radioactivity may be due in part to the presence of naturally occurring emitters, such as potassium (2,380 μ g/L).

Water sample 311SW03 was collected from beneath a floor grate at the center portion of the southern wall. Barium (6.68 μ g/L) was the only RCRA metal detected. Cyanide, cobalt, and beryllium were not detected.

Low levels (<5 pCi/L) of alpha and beta radioactivity were detected, and isotopic uranium activities were not detected.

Water sample 311SW04 was collected from a 5-ft-deep sump at the southern wall in the eastern end of the building. The concrete hole had rust on the walls and contained several pipes that enter the hole from above, bend 90°, and exit the building beneath the southern wall. The standing water in the hole was approximately 1 ft deep at the time of sampling. The only RCRA metal detected was barium (4.45 μ g/L). Beryllium, cobalt, and cyanide were not detected. No radiological activity was detected.

Water sample 311SW05 was collected from a tank near the northwestern corner of the building. The rectangular concrete tank measures 5 ft by 3 ft by 4 ft deep, contained about 30 inches of water covered by a thin film, and contained no sediment. The water contained two RCRA metals, barium and lead (at 22.4 and 342 μ g/L, respectively).

Gross beta activity was detected at 16 pCi/L. Gross alpha activity was less than 1 pCi/L. U-234 and U-238 activities were detected at 0.4 pCi/L each, which is indicative of natural uranium.

Sediment sample 311SED03 was collected from the sump near the southwest corner of Building 311. At the time of sampling, there was no liquid in the sump, and sediment



was scarce. Trichlorofluoromethane was the only volatile compound detected. Detected BNAs include bis(2-ethylhexyl)phthalate, dimethylphthalate, fluoranthene, n-nitroso diphenylamine, phenanthrene, phenol, and pyrene. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant. Neither pesticides nor PCBs were detected at concentrations above 1 μ g/g. Several RCRA metals, including arsenic, barium, cadmium, chromium, lead, mercury, and silver, were detected. Lead was present at 6,800 μ g/g. This may be due to lead associated with the piping in the sump or to lead-containing paint falling from the nearby south wall of the building or from painted portions of the pipes leading into the sump.

A combined gross alpha/gross beta activity of 31 pCi/g was detected. The low total uranium activity is 2.4 pCi/g, which is below the 35 pCi/g limit established earlier.

Sediment sample 311SED04 was collected from a tank in the central portion of the building along the southern wall. The sediment sampled was a $1\frac{1}{2}$ -inch-thick sludge. Acetone (4.47 μ g/g), a common laboratory contaminant, was the only volatile detected. Only one BNA was detected at a concentration greater than 1 μ g/g, n-nitroso-diphenylamine (265 μ g/g). The source of this contaminant is unknown, but it is assumed that the contaminant is used in machining operations. Three pesticides (endrin, dieldrin, and DDT) were detected at concentrations of between 1 and 10 μ g/g. All RCRA metals except for selenium were detected. The presence of lead (2,900 μ g/g) may be due to the proximity of the tank to peeling paint on the south wall, or the sediment may be the residue of a lead-containing petroleum product. Organic results for this sample, however, indicate that the sludge is probably not an oil product.

4.11.1.6 **Building 312**

Sediment sample 312SED01 was collected from a 6-ft-deep hole between the plate shop and one of the beryllium machining laboratories on the ground floor. The hole is near the building's west entrance. No volatiles were detected in the sediment at concentrations of greater than 1 μ g/g. Several BNA compounds were detected at concentrations of greater than 10 μ g/g. These compounds include anthracene, benzo(a)-anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, fluoranthene, and pyrene. The sediment contained six of the eight RCRA metals at concentrations of greater than 1 μ g/g, with only mercury and selenium excluded. Beryllium and cobalt were also detected. The presence of these metals, especially beryllium, is not surprising, since the sample location is adjacent to both the plate shop and the beryllium machining laboratory.

Gross alpha and gross beta activities were detected at activities of 35 pCi/g and 40 pCi/g, respectively. Total uranium activity of 2.3 pCi/g was present in the sample. This is well below the 35 pCi/g soil cleanup level.



4.11.1.7 Building 313

Sediment sample 313NSD01 was collected from a 25-ft-deep dry well in the basement of Building 313N. The sediment was very dry and packed hard. No liquid sample from this location was possible. The sediment sample contained no volatiles, pesticides, or PCBs at concentrations of greater than 1 μ g/g. The only BNA compound detected at a concentration of greater than 1 μ g/g was bis(2-ethylhexyl)phthalate (2.52 μ g/g), a common laboratory contaminant). Four of the eight RCRA metals were detected at concentrations exceeding 1 μ g/g: arsenic (5.74 μ g/g), barium (56 μ g/g), chromium (428 μ g/g), and silver (1.06 μ g/g). In addition, cobalt was detected at 336 μ g/g.

Gross alpha and gross beta activities were detected at 30 pCi/g and 42 pCi/g, respectively, both of which are below the calculated tolerance intervals. Only 1.3 pCi/g of this activity is accounted for by the presence of uranium in the sample, and this value is far below the 35 pCi/g limit. No potassium was detected, which would suggest the presence of other unidentified isotopes and thus account for the remaining gross radioactivity.

Both a sediment sample and a water sample were collected from the large (approximately 75 ft by 25 ft by 20 ft deep) cistern located beneath the western end of Building 313C. A three-dimensional representation of the cistern, based on the only available information, is provided as Figure 4-16. A stagnant odor blended with a slight petroleum smell was noted. The depth of liquid in the cistern was determined to be approximately 8 ft. A thin film on the surface was noted. No volatile or BNA organic compounds were detected in the cistern sediments (sample 313CSED01) at concentrations of above 1 μ g/g. One pesticide (DDD) was found at 1.84 μ g/g in the duplicate sediment sample (313CSED01D) taken from the cistern but not in the routine sample. Seven of the eight RCRA metals were detected in the sample at concentrations of greater than 1 μ g/g, including arsenic (71.7 μ g/g), barium (582 μ g/g), and lead (5,555 μ g/g). In addition, cobalt and beryllium were detected at 101.4 μ g/g and 2.64 μ g/g, respectively.

Both gross alpha and gross beta activities were noted at 92 pCi/g and 105.5 pCi/g, respectively. Uranium was detected at a total activity level (for U-234, U-235, U-238) of 44.4 pCi/g, which exceeds the established soil cleanup level of 35 pCi/g and which accounts for only one quarter of the total radioactivity encountered and less than one half of the beta activity. It is not known where the sediment in the cistern originated (i.e., the roof of Building 313, overland flow from Arsenal Street, Watertown storm sewers, or MTL storm sewers). The remaining radioactivity could be attributed to a number of sources, such as other isotopes received from off-site or from radiological experimentation at the facility; naturally occurring radioactivity in sediments or in the materials from which the cistern was constructed; or discharges of small amounts of radioactive materials to the cistern. A portion of the remaining activity could be attributed to the cobalt $(101.4 \,\mu\text{g/g})$ and potassium $(4,960 \,\mu\text{g/g})$ detected in the sample.



In the water sample taken from the cistern in Building 313C (313CSW01), no volatile or BNA compounds were found at concentrations above the detection limit. No pesticides or PCBs were detected at levels of higher than $1 \mu g/L$. Barium was the only RCRA metal found in the sample. In addition, no beryllium or cobalt was found. The only radioactivity noted was gross beta at only 1 pCi/L.

Based on these results, it appears that the contamination in the cistern sediments is confined to the sediments, and very little of the contamination is of the soluble type. The cistern, which is composed of 10 separate compartments, appears to be relatively stagnant; although based on the site storm sewer map, the cistern appears to be connected hydraulically to the MTL storm sewer system. This connection could not be verified via dye testing due to the large amount of dilution that would have occurred in filling the cistern; however, because the liquid appeared to be clear and because many of the contaminants found in the sediments were not detected in the water, it can be concluded that the cistern, which may have been designed as a flow-through system, is not functioning as such. It is not known whether drainage from rainfall enters the system or whether this would alter the flow regime of the system.

4.11.2 OUTDOOR CONTAINERS

The 11 outdoor containers sampled during Phase 2 include the following:

- A cistern and tank outside Building 100
- A cistern outside the chemical storage building (243)
- A catch basin outside Building 36
- A tank outside Building 43
- A catch basin near Building 37
- A dry well near the propellant storage area
- Two dry wells and two sumps outside Building 311

4.11.2.1 Propellant Storage Area

Sediment sample 000SED01 was collected from a dry well at the southeast corner of the site near the propellant storage area. The sediment in the dry well was sparse, and brick and concrete chips were intermingled with the sediment. No volatile compounds were detected in the sample. Four BNA compounds (benzo(a)anthracene, chrysene, phenanthrene, and pyrene) were detected. Several pesticides were found, although none was detected at a concentration of greater than $1 \mu g/g$. Five of the eight RCRA metals were detected in the sediment sample. In addition, beryllium (less than $1 \mu g/g$) and cobalt were found.

Gross alpha and gross beta activities of 15 pCi/g and 30 pCi/g, respectively, were detected. Uranium isotopes U-234 and U-238 were found in equal proportions (1 pCi/g each). It is not known to what source or sources the remainder of the total alpha and beta activity can be attributed. It is possible that some radiation could be associated with the brick chips found in the sample (depending upon the type of brick), or simply



to natural radiation in the sediment, such as that associated with potassium (1,020 μ g/g in the sample). The facts that U-234 and U-238 are present in equal proportions indicate that the radiation detected is from natural sources only.

4.11.2.2 **Building 36**

Water sample 36SW01 was collected from a catch basin outside the northwest corner of Building 36. The basin is approximately 10 ft deep and contained very little liquid at the time of sampling. Upon lifting the solid cover from the basin, the field team noted an odor resembling that of raw sewage. Four pipes exiting near the bottom of the basin were noted during sampling. The walls were composed of brick and, in some places, concrete block.

Only one volatile organic (methylene chloride, a common laboratory contaminant) was detected in the water from the dry well. No BNA compounds were detected. No pesticides were detected at concentrations of greater than $1 \,\mu\text{g/L}$, although several were found at concentrations of less than $1 \,\mu\text{g/L}$. Only two of the eight RCRA metals (arsenic and barium) were detected in the sample.

Gross alpha and gross beta activities were detected at 4 pCi/L each. No activity was noted from the uranium isotopes. Some of the alpha activity may be due to a natural emitter, such as potassium (3,160 μ g/L).

Sediment sample 36SED01 was collected from the same catch basin as 36SW01. No VOCs were detected in the sediments from this catch basin. Phenanthrene and fluoranthene were detected at 1.57 μ g/g and 1.33 μ g/g, respectively. No pesticides or PCBs were detected at concentrations of greater than 1μ g/g, although several pesticides were detected at concentrations of less than 1μ g/g. Four of the eight RCRA metals were detected in the sediments. In addition, cobalt was detected at 6.25 μ g/g.

Gross alpha and gross beta activities were measured at 13 pCi/g and 27 pCi/g, respectively. U-234 and U-238 were detected at 0.4 pCi/g and 0.5 pCi/g, respectively, which are well below the 35 pCi/g soil cleanup level. The source of the remaining beta activity is unknown but may be due to natural uranium and its daughters or other natural sources.

4.11.2.3 **Building 37**

Sediment sample 37CBSD was collected from a catch basin along the storm sewer system beneath a parking lot to the southeast of Building 37. The sample was composed primarily of dead leaves and other humus materials. The sediment was black and possessed a faint petroleum odor. No volatile organics were found in the sample. Several PAH compounds were found at concentrations above $1\,\mu\rm g/g$, including benzo(b)-fluoranthene, fluoranthene, 2-methylnaphthalene, phenanthrene, and pyrene. Bis(2-ethylhexyl)phthalate (11.2 $\mu\rm g/g$) was detected at the highest concentration in the sample. Only one pesticide was detected in the sample (DDD). Two of the eight RCRA



metals were detected (barium and chromium). In addition, both beryllium and cobalt were detected, although the beryllium concentration was less than $1 \mu g/g$.

Gross alpha and gross beta were detected at 19 pCi/g each. Of the total activity of 38 pCi/g, only 1.9 pCi/g can be attributed to uranium isotopes. The presence of the BNA compounds listed above may be attributed to runoff from Arsenal Street, since benzo(b)fluoranthene, fluoranthene, phenanthrene, and pyrene are known to be components of asphalt and of exhaust gases from gasoline engines, and since the catch basin is hydraulically connected to the storm sewer line along Arsenal Street. During storm events, backwash from Arsenal Street may have entered the basin.

4.11.2.4 **Building 43**

Water sample 43SW01 was collected from an outdoor dry well drain near the northwest corner of Building 43. It is also in close proximity to an underground vault containing two fuel oil tanks. Chloroform and methylene chloride (both common laboratory contaminants) were the only volatiles detected in the sample. No pesticides or PCBs were detected at concentrations of greater than 1 μ g/L. The only RCRA metal found in the water sample was barium (8.68 μ g/L). Neither beryllium nor cobalt was found.

The gross alpha and beta activities (1 and 2 pCi/L, respectively) are low despite the close proximity to the DU melting area in the Building 43 "lean-to." U-238 (0.7 pCi/L) was the only uranium isotope detected, and it was present at an activity of below the 1 pCi/L limit.

4.11.2.5 **Building 242**

A liquid sample (242SW01) was collected from a large cistern south of the reactor building. The cistern was approximately 30 ft by 30 ft by 18 ft deep. The liquid was clear, and no sediment was present in the cistern. The only VOC detected in 242SW01 was methylene chloride (29.3 μ g/L), a common laboratory contaminant. The only RCRA metal detected was barium (9.14 μ g/L). In addition, cobalt and beryllium were not detected.

A gross beta activity of 17 pCi/L was detected in the sample; however, none of the uranium isotopes was found. Potassium (detected at 8,700 μ g/L) may be partially responsible for the high beta activity.

A sediment sample (242SED01) was obtained from a catch basin adjacent to the cistern from which 242SW01 was acquired. The basin is approximately 10 ft deep, and the catch basin hole (in the top 3 to 4 ft) is approximately 2 ft wide. The width of the bottom portion could not be determined. No VOCs were detected in the sample. Several BNAs, including benzo(a)anthracene, chrysene, fluorene, and pyrene were detected. No pesticides or PCB aroclors were found at concentrations of greater than $1 \,\mu g/g$. Six of the eight RCRA metals were detected in the sample, as were beryllium and cobalt.



The catch basin contained 19 pCi/g of gross alpha activity and 22 pCi/g of gross beta activity. Uranium 234 and uranium 238 were detected at 1 pCi/g each. Uranium 235 was not detected.

4.11.2.6 **Building 243**

The cistern outside of Building 243 (the chemical storage building) is reported to have received a spill from the storage building in the late 1970s. For this reason, a dye test was conducted to determine if in fact any of the floor drains in Building 243 lead into the cistern. In addition, both a sediment (243SED01) and a water (243SW01) sample were collected from this cistern. Inspection of the cistern showed three pipes leading into the cistern. It was discovered via dye testing that a floor drain, a sink drain, and an eyewash station drain from Building 243 empty into the cistern.

Sample 243SED01 was collected from a black, silty, watery sludge that had an oil-like sheen and a distinctive odor. While no VOCs were detected, several BNA compounds were detected, indicating that the sheen and the odor could be attributed to the presence of a petroleum product. Among the BNAs detected were 2-methylnaphthalene (5.87 μ g/g), acenaphthene (13.1 μ g/g), benzo(a)anthracene (40.8 μ g/g), bis(2-ethylhexyl)phthalate (102 μ g/g), fluoranthene (70.3 μ g/g), phenanthrene (77.2 μ g/g), and pyrene (54.1 μ g/g). Several pesticide/PCB compounds, including DDD, beta endosulfan, and endrin ketone were detected at levels above 1 μ g/g. Four of the eight RCRA metals (barium, cadmium, chromium, and lead) were detected in the sample. The highest of the reported concentrations for the RCRA metals was for chromium (68.3 μ g/g). Gross alpha and gross beta activities of 11 pCi/g and 25 pCi/g, respectively, were noted in the cistern sediments.

Sample 243SW01 was taken from the liquid portion of the cistern contents. Several VOCs were detected at concentrations above 1 μ g/L. These compounds include 1,2-dichloroethylene, acetone (a common laboratory contaminant), benzene, chloroethane, methylene chloride (a common laboratory contaminant), and TCE. The only BNA compound found in the liquid sample was bis(2-ethylhexyl)phthalate (another common laboratory contaminant). Of the eight RCRA metals, arsenic, barium, cadmium, and chromium were detected in the cistern liquid. In addition, beryllium and cobalt were detected. Gross alpha and gross beta activities were reported at 29 pCi/L and 52 pCi/L, respectively. Of these, 2.4 pCi/L can be attributed to isotopes U-234 and U-235, while 5.9 pCi/L is from U-238. This would indicate that, while much of the radioactivity in the liquid cannot be attributed to uranium, the predominant form of uranium present is DU. The remainder of the radioactivity noted can be attributed in part to the presence of a large amount of potassium (10,400 μ g/L) in the cistern water.

4.11.2.7 Building 311

Water sample 311SW01 was collected from a sump just outside the southwestern corner of Building 311. The sump is estimated to be approximately 10 ft deep. Only two VOCs, acetone (170 μ g/L) and methylene chloride (34.3 μ g/L), were detected in the



sample. These are common laboratory contaminants and therefore may not actually be present in the sample. No BNAs were detected in the sample. No pesticides or PCBs were detected at concentrations of greater than 1 μ g/L in the sample. Only one RCRA metal (barium, 5.33 μ g/L) was detected. Beryllium, cobalt, and cyanide were not detected. The only radioactivity detected was gross beta activity at 2 pCi/L. No uranium was detected.

Sediment sample 311SED01 was collected from a dry well outside the northern wall of Building 311 towards the eastern end of the building. The depth of the dry well is estimated at 3 ft. No organic compounds were detected, in the sediments from this dry well; however, five of the eight RCRA metals were detected, as well as cobalt. The RCRA metal found in the highest concentration was lead (4,400 μ g/g). The dry well is very close to (and downslope of) Arsenal Street, and the street traffic may have contributed to the lead in the dry well via leaded automobile gasoline. Gross alpha and beta activities were detected at 40 pCi/g and 34 pCi/g. Based on the isotopic analyses conducted, it appears that only 3.4 pCi/g of this activity is attributable to uranium. The U-238 to U-234 ratio of 1:6 indicates that the uranium may be in both its natural and depleted forms. Therefore, uranium daughters may be contributing to overall beta activity. A potassium content of 1,920 μ g/g in the sample is also a contributor to the overall radioactivity noted.

Sediment sample 311SED02 was collected from a dry well outside the northern wall of Building 311 to the west of 311SED01. As with 311SED01, this dry well is estimated to be approximately 3 ft deep. No volatile organics or BNA compounds were detected in this sample. In addition, no pesticides or PCBs were detected at concentrations of greater than $1\,\mu g/g$, although several such compounds were detected at concentrations ranging between 0.05 and 0.85 $\mu g/g$. Five of the eight RCRA metals were detected at concentrations of greater than $1\,\mu g/g$, and one (mercury) was detected at just above 0.5 $\mu g/g$. In addition, beryllium and cobalt were found at concentrations of 0.898 $\mu g/g$ and 15.1 $\mu g/g$, respectively. Gross alpha and beta activities were detected at 38 pCi/g and 32 pCi/g, respectively. Of these activities, only 2.1 pCi/g can be attributed to the presence of uranium isotopes. The presence of metals and radiological activities may be attributed to machining and storage practices within Building 311 as well as to the presence of potassium at 1,740 $\mu g/g$. In addition, some of the metals present may be the result of urban runoff from other parts of the developed area surrounding MTL.

4.11.3 SUMMARY

During Phase 2, a total of 26 containers were sampled at MTL. A summary of the major contaminants found during the Phase 2 container investigation is presented in Table 4-60. The organic compounds detected were primarily PAHs, as described above; however, a few pesticides were detected in water and/or sediments from several of the containers sampled. For instance, the cistern outside Building 243 (the chemical storage building) contained several pesticides in both the liquid and sediment samples at concentrations above 1 μ g/L and 1 μ g/g, respectively. This cistern was the only container with concentrations of pesticides above 1 μ g/L in its liquid contents; however,



four containers had sediment concentrations of pesticides (most notably DDD and DDT) that were above background levels. The samples containing such levels were found at two outdoor locations (one on the east side of MTL and the other on the west side) and at two indoor locations (Buildings 313C and 311). In addition, as outlined above, appreciable concentrations of numerous RCRA metals and beryllium and cobalt were found in containers in different parts of the facility.

Human exposure to contamination found in the containers at MTL is highly unlikely, so the presence of these compounds is not of concern from a health risk perspective; however, the results can be used to characterize container contents for disposal. A comparison with RCRA Toxicity Characteristic Leaching Procedure (TCLP) limits was performed, which assumed that all of the RCRA metals contained in the sample were leached in the TCLP test. This comparison indicated that no TCLP limits would be exceeded by any of the samples except for lead in the sediment samples from the cistern beneath Building 313C.

From a radiological standpoint, alpha, beta, and isotopic uranium activities were found in those containers associated with, or in close proximity to, buildings where DU operations have been conducted. In addition, it was found that in many instances, other sources such as naturally occurring uranium, uranium daughters, and potassium were contributing to the total radioactivity.

4.12 QA/QC DATA

Relevant portions of the Quality Assurance/Quality Control (QA/QC) and the Data Management Plans have been provided in Appendices T and U, respectively. The plans were taken from the Technical Plans for the Army Materials Technology Laboratory (WESTON, March 1991). The QA/QC Plan discusses the project QA/QC organization and responsibility, sampling protocol, recordkeeping, system controls, and corrective actions. The Data Management Plan discusses sampling and analysis data, and the Installation Restoration Data Management Information System (IRDMIS) database.

4.12.1 DUPLICATES

Duplicate samples for groundwater, soils, sediments, surface water, and wipes were collected following the protocol in the Technical Plans for the Materials Technology Laboratory (WESTON, March 1991) and are discussed below. The degree of variation between the sample values (not including values below the quantification limit) is presented in Table 4-57 by media.

4.12.1.1 Groundwater

Of the values for groundwater, 75% of duplicates were within 10% of the value of the original sample and only one duplicate was not within 20% of the original sample. These data indicate reasonable agreement between the groundwater results, as would



be expected. Groundwater sample results generally show little variation due to the homogeneous characteristics of liquid samples.

4.12.1.2 Surface Water

Of the values for surface water (both environmental and nonenvironmental samples), 70% of duplicates were within 10% of the original sample and only 12% were not within 30% of the original sample. These data indicate reasonable agreement between the surface water results. Surface water sample results generally show little variation due to the homogeneous characteristics of liquid samples. It should be noted that the nonenvironmental samples (container samples) had, in general, a larger degree of variation as compared to the environmental samples. No environmental surface water duplicate samples exceeded 20% variation.

4.12.1.3 Soils

Of the values for soil, 40% of duplicates were within 10% of the original sample and only 30% were not within 30% of the original. These data indicate reasonable agreement between the soil results. Soil sample results tend to show more variation, in general, due to the nonhomogeneous nature of solid samples. It should be noted that the samples that generally showed the greatest variation (>100%) were pesticide analysis. Many of the concentrations were near detection limits, where a small variation in concentration produces a large percent variation.

4.12.1.4 Sediments

Only 8% of the duplicates for sediments (both environmental and container samples) were within 10% of each other and 79% were not within 30% of each other. It should be noted that the nonenvironmental samples (container samples) had a larger degree of variation. This follows the same pattern as the nonenvironmental surface water samples but to a greater degree. Of all the duplicate sediment samples, 21% were greater than twice the original sample and all were container samples. Of the container results, 41% of the duplicate samples were greater than twice the original sample. Sediment sample results tend to show more variation, in general, due to the heterogeneity of solid samples. Sediments in containers do not encounter the random mixing forces that river sediments do. As with the soil samples, the pesticides analysis showed the greatest variation (>100%) in the sediment duplicates.

4.12.1.5 Wipes

Of the results for wipes, 20% of duplicate samples were within 10% of the original sample and 52% of duplicate were not within 30% of the original. The wipe duplicate samples were actually replicate samples, since the duplicate wipe was collected adjacent to the regular wipe sample. Replicate samples would generally have a higher variation between samples because of the non-homogeneous characteristics of replicate samples.



The replicate samples could have been taken from a more or less contaminated surface than the regular sample, even though they were collected adjacent to each other.

4.12.2 FIELD BLANKS

Field blank samples were collected following the protocol in the Technical Plans for the Materials Technology Laboratory (WESTON, March 1991) and are used to evaluate whether any contamination is being introduced by the field sampling team, equipment, or the laboratory. Field blank samples collected during the Phase 2 RI included rinse blanks, trip blanks, and glove/solvent blanks for wipe samples. The field blanks are discussed on a medium-by-medium basis. Air-filled blank samples were previously discussed and presented in Subsection 4.10.1.

4.12.2.1 Soils

Field blank samples collected during upgradient sampling contained levels of methylene chloride (28.3 and 37.4 μ g/L) and chloroform (2.1 and 2.5 μ g/L). Aluminum (118 and 128 μ g/L) was detected in two samples, while zinc (24 to 40 μ g/L) was detected in four. Mercury was detected in one sample at 0.3 μ g/L. Gross beta and thorium-230 were detected in one sample at 1 and 0.2 pCi/L, respectively. U-234 was detected in three samples at levels ranging from 0.1 to 1.2 pCi/L. U-238 was detected in two samples at 0.6 and 0.1 pCi/L, respectively.

In field blanks collected during downgradient sampling, methylene chloride appeared 11 times from 13 to 87 μ g/L, and chloroform appeared 7 times from 1 to 2.5 μ g/L in both equipment rinse blanks and VOA trip blanks. These compounds are common laboratory contaminants, so detections of these compounds in soil would be questionable. Acetone was detected in one sample at 84 μ g/L. Chloromethane was detected in two samples (1.4 and 2.2 μ g/L). Organics 1,3,5-trinitrobenzene, DDT, and PCB 1260 were all detected once at levels below 0.4 μ g/L. Several inorganics/metals appeared in samples, including aluminum, barium, beryllium, calcium, iron, mercury, sodium, nitrate, and zinc. Zinc was detected 18 times, ranging from 26 to 88 μ g/L, aluminum was detected 6 times from 142 to 647 μ g/L, and calcium was detected six times from 127 to 856 μ g/L. Beryllium was detected once at 1.2 μ g/L. Gross alpha ranged from 1 to 2 pCi/L in eight samples, while gross beta ranged from 1 to 10 pCi/L in nine samples. U-234 was detected six times between 0.1 and 0.3 pCi/L, while U-238 was detected three times between 0.1 and 0.4 pCi/L.

4.12.2.2 Groundwater

Field blank results for groundwater showed few compounds present in either trip blanks or rinse blanks. Chloroform and toluene were present at approximately $1 \mu g/L$ in field blanks associated with upgradient samples. Nitrate was detected at 1,400,000 $\mu g/L$; therefore, nitrate concentrations in associated site samples must be questioned. Aluminum and copper were present at 166 and 22 $\mu g/L$, respectively. Gross beta and



U-234 were present at 2 pCi/L and 0.3 pCi/L, respectively. No other compounds were detected in the other upgradient samples.

Downgradient well field blank samples, in general, were contaminant free. Chloroform was detected at $1\,\mu g/L$ in two samples. Copper was detected twice in the $20\,\mu g/L$ range, while nitrate was detected several times at approximately $2,000,000\,\mu g/L$. Sodium was detected once at approximately $40\,\mu g/L$. Radiological parameters detected included gross alpha (twice at $1\,p Ci/L$), gross beta (several times in the 1 to $2\,p Ci/L$ range), and U-234, once at $0.1\,p Ci/L$.

4.12.2.3 Charles River

No chemical contaminants were detected in the Charles River surface water field blank samples. Gross beta activity was detected in a field blank associated with downstream sample at 1 pCi/L.

Upstream sediment rinse blanks contained barium and zinc at 5.2 and 35.7 $\mu g/L$, respectively, as well as gross alpha at 1 pCi/L. Downstream sediment rinse blanks contained calcium, iron, sodium, and zinc. Calcium and sodium were detected twice at levels between 160 and 265 $\mu g/L$ and 410 to 650 $\mu g/L$, respectively. Zinc was detected several times between 20 and 50 $\mu g/L$. Iron was detected once at 95.7 $\mu g/L$. U-234 and U-235 were detected at 0.5 and 0.7 pCi/L.

4.12.2.4 Storm Sewers

No chemical contaminants were detected in the storm sewer surface water field blank samples.

4.12.2.5 Indoor Surface Chemical Sampling

Indoor surface chemical (wipe) glove field blank samples showed no contaminants present. Solvent blank samples that were waved into the air before placement into the sample jars showed levels of common metals/inorganics. Levels of aluminum, calcium, chromium, copper, iron, magnesium, sodium, and zinc were detected in 20 to 50 solvent blank samples each, as summarized in Table 4-59. Other metals/inorganics were only detected once or twice at low levels and included silver, arsenic, barium, cyanide, mercury, nickel, nitrate, and lead. Few organic compounds were detected in the solvents. Organics detected at low levels include butylbenzyl phthalate, bis(2-ethylhexyl) phthalate, methyloxychlor, beta-endosulfan, endrin, and DDD.

4.12.2.6 Container Sampling

Container surface water field blank samples showed methylene chloride, a common laboratory contaminant, present in two samples between 10 and 11 μ g/L. PCB 1260 was detected in one sample at 0.4 μ g/L. Inorganics/metals detected included aluminum, barium, calcium, chromium, copper, iron, sodium, and zinc. Aluminum was detected six



times, ranging from 117 to 191 μ g/L; calcium (118-214 μ g/L), sodium (389-613 μ g/L), and zinc (22.8-35.1 μ g/L) were detected several times. Barium, chromium, copper, and iron were only detected once at 6.4, 22.1, 22.3, and 136 μ g/L, respectively. Gross beta was detected in four samples ranging from 2 to 3 pCi/L. Gross alpha and thorium-230 were detected in one sample each at 1 pCi/L and 0.1 pCi/L, respectively. U-235 and U-238 were detected in one sample at 0.5 and 0.1 pCi/L, respectively.

Container sediment field blank samples showed levels of aluminum, calcium, sodium, zinc, gross beta, and thorium-230. Aluminum (114 to 177 μ g/L), calcium (157-170 μ g/L), and gross beta (1 pCi/L) were detected in three samples. Sodium was detected once at 381 μ g/L, while zinc was detected twice at 20 μ g/L.

4.12.2.7 Significance of Field Blank Sampling

The field blank samples indicate that no gross contamination was introduced into the samples by the field sampling team. In general, the field blank samples did not affect the analytical results. The concentrations of the few compounds detected in the field blank samples were generally much less than the measured values. In all media, the radiological results of the field blanks were indicative of background radiological conditions.

The analysis of field blank samples indicated a potential impact on groundwater results for nitrates. The concentration for nitrates in four groundwater rinse blank samples (C-3-RB, MW-11-RB, MW-08RB, and MW-16-RB) ranged from 1,400,000 to $2,200,000~\mu g/L$.

The chemical concentrations in field blank samples for Charles River surface water were insignificant compared to measured values, so they do not affect the surface water results. Similarly, the results of field blank analyses do not affect the Charles River sediment analytical results. None of the five compounds that currently have draft national sediment quality criteria was detected in the field blank samples.

As a conservative assumption, no chemicals were deleted from the list of chemicals of potential concern in the risk assessment based on detection in blank samples.

4.12.3 LABORATORY BLANKS

The following discussion will present the evaluation of the laboratory blanks completed by the laboratory. Laboratory blank samples were collected following the protocol in the Technical Plans for the Materials Technology Laboratory (WESTON, March 1991) and are used to evaluated whether any contamination was introduced by the laboratory.

Five compounds in four soil/sediment lots and three compounds in one liquid lot may be attributed to laboratory contamination. The compounds in the soil/sediment lots include benzo[a]fluoranthene, beryllium, benzo[b]fluoranthene, chrysene, and PCB 1260. The compounds in the liquid lots include cadmium, lead, and selenium.



The concentrations of the chemicals in the blank samples were lower than compounds detected on site. In addition, due to the large amount of data collected and the number of data lots produced, blank detection in five lots will not have a measurable effect on the overall quality of the data.

As a conservative assumption, no compounds were omitted from the risk assessment based on detection in blank samples.

4.12.4 TENTATIVELY IDENTIFIED COMPOUNDS

As part of the Phase 2 RI, tentatively identified compounds (TICs) were identified from analysis of both wipe and media samples. In both cases, AEC standard TIC management protocols were used to attempt to identify TICs. A detection is classified as a TIC if the detection fingerprint cannot be matched with a library fingerprint with greater than 95% confidence.

Table 4-60 presents the types of TICs (VOA and SVOA) detected in samples collected for soils and Charles River sediment and surface water. TIC volatiles are not considered to be of concern in soil and Charles River sediment and surface water samples because of the infrequency of detection, as indicated by Table 4-60. TIC semivolatiles are not considered to be of concern in Charles River surface water samples, again because of the infrequency of detection, as indicated by Table 4-60.

As a result of the frequency of detection of TIC semivolatiles in soil and Charles River sediment samples, TIC semivolatiles were evaluated more extensively, as indicated in Table 4-61. Table 4-61 presents the TIC semivolatiles detected greater than 10 times in soil samples (both surface soil and boring samples). The TICs could not be located for several samples; therefore, Table 4-61 presents the evaluation of 1,757 of the total 1,857 TICs detected. The following compounds were detected in nine or more sampling units: benzo[e]pyrene, hexadecanoic acid, unknowns, unknown polycyclic hydrocarbons (PAH), unknown long chain hydrocarbons, unknown long chain oxy hydrocarbons, and polynuclear aromatics with molecular weights of 192 and 216. Since the carcinogenic potential of PAHs vary from noncarcinogenic to highly carcinogenic, nothing can be stated about (or quantified) with regard to a range of PAHs based on molecular weights. All of these compounds were detected in upgradient samples also. Identification of these TICs into general classes of compounds only, except benzo[e]pyrene and hexadecanoic acid, makes evaluation of these compounds difficult.

The following TICs were detected 15 times or more within a sampling unit: polynuclear acid in Unit 6, polycyclic hydrocarbon in Unit 12, polynuclear aromatic (molecular weight = 216) in Unit 8 and upgradient, polynuclear aromatic in Units 9 and 12, and unknown long chain oxy hydrocarbon in Units 5 and 13. Again, the significance of these TICs is difficult to evaluate because of their classification into general groups. However, the list of identified PAHs detected in each of these areas was evaluated as part of the baseline risk assessment (Section 6).



Review of the TIC data indicated the sediments contained approximately the same types of TICs and in the same proportions detected in the soils. The TICs detected in downgradient samples were also detected in upgradient samples, indicating the detected TICs cannot be attributed solely to the facility.

4.12.5 IRDMIS DATABASE SYSTEM

AEC environmental sampling data were managed through the IRDMIS database system. The IRDMIS database system is managed and maintained by Potomac Research Institute (PRI).

The data management process began when the samples were collected in the field and sent to the laboratory for analysis. The laboratory analyzed the samples, in lots, for the parameters requested on the chain-of-custody. Control charts were produced for each lot of samples analyzed. The collected raw data from the analysis were then entered into the PC Data Entry and Validation Subsystem.

Control charts were established and maintained to track the performance of each analytical method for each analyte. Data to be used in control charts were derived from certification data and daily control samples. Percent recoveries were calculated by subtracting the instrument response value of the method blank from the instrument response value of the method spike. The found concentration (corrected for the blank) of the method spike was divided by the amount of spike, and multiplied by 100. These data were not corrected for accuracy.

The data were classified as 1 of 3 levels. The levels distinguished between different computer file formats. The three different levels are:

- Level 1 the data are in the PC Data Entry and Validation Subsystem computer file format.
- Level 2 the data are in PRI's processing file format.
- Level 3 the data are in the IRDMIS system database computer file format. Level 3 is the ultimate destination for the data. When the data have been processed to Level 3, the data can be retrieved from the IRDMIS.

The control charts were sent to the AEC chemistry group for review to determine whether the data was acceptable or should be rejected. If the data were accepted, no action needed to be taken by the AEC chemistry group and the submitted data were processed by PRI to Level 3 file format. If the data were rejected, the AEC chemistry group took one of several actions:

The rejected lot was deleted from the IRDMIS database entirely.



- The AEC chemistry group gave the data a flagging code to show the data had an error.
- The AEC chemistry group and the laboratory alleviated the problem.

If two consecutive spikes at twice the CRL were not detected, the method was considered out of control.

An out-of-control condition did not automatically require sampling or reanalysis. The data were reviewed daily to determine if the specific analyses were under control at the time of analysis.

The uncorrected value was processed by PRI through a QA program. The QA program applied accuracies to the uncorrected values. The accuracies took into account the analysis, the analytical method, the particular laboratory, and the percent moisture and dilution of the sample. The QA program processed the uncorrected values into what was referred to as "corrected values."

Section 5 Contaminant Fate and Transport



SECTION 5

CONTAMINANT FATE AND TRANSPORT

The transport of chemicals at the MTL site is influenced by the environmental characteristics of the site and surrounding area, the characteristics of source areas, and the physical/chemical characteristics of the chemicals. The site environmental factors and source area characteristics have been addressed in Sections 3 and 4 of this report. The physical/chemical characteristics of the detected chemicals are addressed below.

5.1 PHYSICAL AND CHEMICAL PROPERTIES OF DETECTED CHEMICALS

The chemicals detected can be classified into general categories according to their similarity in chemical structure and/or physicochemical properties (i.e., factors that would influence mobility and transformation in the environment). The categories of the chemicals found at MTL are listed below:

- VOCs
- Semivolatiles (BNAs and PAHs)
- Pesticides
- Aroclors (PCBs)
- Explosives
- Metals
- Other inorganics
- Radiological parameters

Table 5-1 summarizes the detected chemicals found within each site medium. The risk assessment evaluates these chemicals to produce a list of chemicals of potential concern (see Section 6).

Table 5-2 summarizes the numerical values of the physicochemical properties of representative organic chemicals that are germane to transport processes. The physicochemical properties of metals and other inorganic chemicals are not presented in a similar tabular format because migration for these chemicals is greatly dependent upon external factors that are identified as part of a site investigation. These include several site-specific factors, such as the identity of other ions that enhance or limit mobility through competitive complex formation; the pH of the medium; the cation exchange capacity of the soil; the presence of humic materials, hydrous oxides, silicates, and carbonate minerals; oxidizing or reducing conditions; and the presence of microbes. Moreover, physicochemical properties such as solubility depend upon the identity of the metal complex, which is rarely known; however, a qualitative discussion of potential migration of metals will be included in this section.

A brief discussion follows on the relevance of the physicochemical parameters listed in Table 5-2 that are most frequently used to evaluate mobility of organic chemicals.

5-1



The water solubility of a substance is a critical property affecting environmental fate; highly soluble chemicals can be leached from wastes and soils and are mobile in surface water and groundwater.

Volatilization of a compound from environmental media will depend on its vapor pressure, water solubility, and diffusion coefficient. For estimating releases from water to air, the Henry's Law constant, the partition coefficient that expresses the ratio of the chemical concentration between air and water at equilibrium, is more appropriate than vapor pressure alone. Although it is frequently reported for volatile chemicals, the Henry's Law constant can be estimated for chemicals of low aqueous solubility (less than a few percent) by the ratio of vapor pressure and solubility at the same temperature (Mackay and Shiu, 1981). Compounds with Henry's Law constants in the range of 10^{-3} atm m³/mole and larger can be expected to volatilize readily from water; those with values ranging from 10^{-3} to 10^{-5} atm m³/mole are associated with significant, but lesser volatilization, while compounds with values less than 10^{-5} atm m³/mole volatilize from water only to a limited extent (Lyman et al., 1982).

The octanol-water partition coefficient (K_{ow}) is often used to estimate the extent to which a chemical will partition from water into lipophilic parts of organisms (e.g., animal fat). The higher the K_{ow} value, the greater is a chemical's tendency to partition into fat. Similarly, the organic carbon partition coefficient (K_{oc}) reflects the propensity of a compound to adsorb to the organic carbon found in soil. The higher the K_{oc} value, the greater is a chemical's tendency to adsorb to soil organic carbon instead of migrating through groundwater. For example, large nonpolar compounds such as DDT and PCBs have high K_{oc} values (exceeding 10^5) and are relatively immobile. By contrast, small or more polar compounds such as toluene and vinyl chloride have low K_{oc} values (less than 10^3) and are relatively mobile. In addition to organic carbon, adsorption to soil is also a function of the surface area of the soil particle, as well as the size, shape, and surface area of the adsorbing molecule.

5.2 MECHANISMS OF MIGRATION AND TRANSFORMATION AT THE SITE

Information on site characteristics, sampling data presented in Section 4, and the information on physicochemical properties given above can be used to determine the potential mechanisms of migration and transformation that may occur. This discussion is organized according to the media sampled: containers, soils, groundwater, storm sewers, surface water, Charles River sediments, and indoor air.

5.2.1 CONTAINERS

The container samples were not environmental samples. Instead, they served to characterize what had been stored historically. In general, leakage from containers can result in contamination of other site media (typically soils and groundwater, through which contaminants may eventually reach the river). To reduce the risk of leakage, MTL leak-tests tanks. Since sampling, many of the underground tanks have been removed.



5.2.2 **SOILS**

There does not appear to be a strong correlation between soil contaminants of concern and those detected in containers, indicating that soil contamination has originated from additional sources, such as past site operations.

There are two primary pathways for migration of soil contamination to other media. The first pathway involves erosion and runoff to storm sewers and the Charles River surface water and sediments. There is evidence that this has occurred, as described in the subsequent subsections.

The second pathway involves leaching of contaminants to groundwater. Contaminants in shallow groundwater may be transported to the river. It is important to note that many of the soils at the MTL site consist primarily of sands and fill, which will not immobilize contaminants as effectively as soils containing higher percentages of clays or organics (e.g., humus). Consequently, some releases may have passed readily through site soils to groundwater.

More than half of the chemicals detected in soil have also been detected in groundwater. The migration of several of these contaminants is discussed below.

Chloroform, TCE, PCE, 1,1,2,2-tetrachlorethane, and methylene chloride are chlorinated VOCs. Due to their relatively high solubility in water and low $K_{\rm oc}$ values, they are considered highly mobile. Consequently, these contaminants leach readily from soils to groundwater.

Benzo(a)anthracene is a high-molecular-weight BNA; pp-DDE and pp-DDT are pesticides. All three of these contaminants are typically considered immobile in soils; however, they may pass through soils with very low organic content (e.g., sand). The biodegradability of these and most other high-molecular-weight compounds is low.

Cadmium, chromium, and lead are metals. As described earlier, migration of inorganic compounds through soils is a highly complex process and, therefore, very difficult to predict. It is relevant to note that all of the metals identified in soil were also identified in containers.

5.2.3 GROUNDWATER

Shallow groundwater beneath the MTL site flows into the Charles River. Therefore, contaminants in shallow groundwater may migrate to the river. It is relevant to note that the Charles River downgradient from the site is not used as a source for drinking water.

Most of the chemicals detected in groundwater were also found in site soils. Seven of the compounds are chlorinated VOCs that migrate relatively quickly in groundwater. The remaining contaminants not found in soil samples either migrated to groundwater



by passing readily through soils with low organic content (e.g., sands), leached out of site soils down to nondetect levels, or have an off-site source.

Reductive dechlorination of many of these chlorinated solvents has been observed in groundwater under anaerobic or low-oxygen conditions to be sequential: PCE yields TCE, which yields 1,2-dichloroethylene, which yields vinyl chloride. Vinyl chloride, the most toxic of these compounds, can be biodegraded to ethylene, although this final reaction can be quite slow. Vinyl chloride was not detected in groundwater during Phase 2. Concentrations of the chlorinated solvents in the groundwater may not be high enough to sustain significant biological activity and degradation; however, insufficient nutrients and other carbon sources also may limit biodegradation.

The fuel-related compounds in C-2 (benzene, ethylbenzene, xylenes, and toluene) are relatively mobile in soil-water systems with partition coefficients several orders of magnitude lower than most of the compounds found in MTL soil samples. Their migration can be mitigated by volatilization and (aerobic) biodegradation.

5.2.4 STORM SEWERS

Contaminants in the storm sewers can migrate through the system and eventually to the Charles River by several transport mechanisms. Dissolved chemicals can migrate through the system in the water itself. Less mobile compounds that adsorb to sediment particles can be transported if the particles become suspended in the water during the events. Few or no sediments were observed in most of the manholes, as transport of sediment-absorbed contaminants, if occurring, appears to be limited to the first flush of the storm event when sediments may be carried into and out of the system. The only exception was at location SW-14P, where sediments have accumulated in the outlet line. These sediments most likely have migrated from the river rather than the site, since the manhole invert is approximately 3.5 ft below the outlet pipe, and a large depth of sediments would have to accumulate in the manhole in order to flow into the outlet pipe.

A total of 31 contaminants of potential concern, 13 of which are pesticides or pesticide derivatives, were detected in storm sewers. The pesticides are likely the result of historical application at the site and nearby community. Some of these same compounds were found in the Charles River (primarily in sediment), including upstream of the site.

The other contaminants have also been identified in containers or in site soils. Therefore, it appears likely that stormwater runoff has carried these contaminants to the storm sewers.

5.2.5 SURFACE WATER

In general, contaminants in the Charles River have the potential to migrate downstream and into Boston Harbor. In doing so, any concentrations would be greatly



diluted. The Charles River downgradient from the site is not used as a source for drinking water.

No PCBs or explosives were identified as potential contaminants of concern in surface water (i.e., the Charles River). Twenty-three chemicals were identified. Of these, most appear to be linked to the site, apparently due to stormwater runoff. The migration of several contaminants is discussed below:

- TCE and toluene are also site soil contaminants.
- 1,3-dimethylbenzene (m-xylene) was also detected in groundwater, both upgradient of and on the site.
- Some of the low levels of gross beta activity, U-234, and U-238 are believed to be site-related but are localized around outfalls only.

5.2.6 CHARLES RIVER SEDIMENTS

All of the chemicals detected in Charles River sediments were detected in other site media. Upstream flow and stormwater runoff are the likely migration pathways. These contaminants include 20 BNAs, 12 pesticides, 19 metals, cyanide, and gross beta activity. It is relevant to note that the gross beta activity is localized around outfalls and is not migrating.

5.2.7 INDOOR AIR

Migration of indoor air contaminants does not appear to be a concern. The sporadic detection of indoor air contamination occurred in highly localized areas (e.g., chemical storage areas, open vats and containers, ongoing operations, and residual surface contamination). Since indoor air contamination is highly localized and the buildings are generally compartmentalized, migration of indoor air contamination does not appear to be a concern. Occupational air monitoring will be used for those operations that have the potential to affect worker health and safety during remediation activities.

Section 6 Baseline Risk Assessment of Human Health Effects

SECTION 6

BASELINE RISK ASSESSMENT OF HUMAN HEALTH EFFECTS

The purpose of this baseline risk assessment is to evaluate the potential for adverse effects to future populations at the MTL as the result of exposure to hazardous substances under conditions of the no-action alternative, that is, in the absence of any remedial actions to control or mitigate exposures to or releases of toxic substances. The evaluation in this section is intended to provide information that can be used to decide what clean up activities are needed to prepare the MTL for future reuse.

6.1 INTRODUCTION

6.1.1 APPROACH

This Section of the RI report looks at the possibility that contamination detected at the MTL might affect the quality of health of those people who might use the MTL after it is closed. Risk assessments, in general, are four-step processes. First the sampling results described in Section 4 are looked at to determine what chemicals should be evaluated. Secondly, there is an analysis to decide if those chemicals are present at or could migrate to places where people are likely to come in contact with contamination. This is termed the exposure assessment and an attempt is made to actually quantify how often and how much a person could be exposed at a given location. In the third step the information regarding how toxic a chemical could be is assembled using information both from animal studies and reports of human exposures. In the last step, estimates of risks are calculated using the information developed in both the exposure assessment and the toxicity assessment (Steps 2 and 3). Once those estimates are generated, a number of statements regarding how certain or uncertain they are must be made. This allows the reader to better understand where conservative and nonconservative assumptions are made and their effect on the estimated risk numbers.

The procedures used in this risk assessment are consistent with guidance from the Massachusetts Department of Environmental Protection (MADEP) for evaluating risk from residential exposures (MADEP, 1992) and for conducting risk characterizations according to the Massachusetts Contingency Plan (MDEQE, 1989). Additional guidance was provided by the U. S. Environmental Protection Agency (EPA) Risk Assessment Guidance for Superfund (RAGS) - Human Health Evaluation Manual (EPA, 1989c), RAGS Supplemental Guidance - Standard Default Exposure Factors (EPA, 1991a). Other guidance and technical information were used where appropriate. This risk assessment replaces an earlier version released October, 1992.

6.1.2 SCOPE

There are two issues that define the scope of this risk assessment. First, only possible exposures to future populations are addressed. The focus of this assessment is to answer the following question - What is the risk of using this site under foreseeable future conditions once the site is closed? With this in mind the evaluation looks at all

the ways exposure to contaminants could occur if no cleanup is done. This also means that current on-site activities are <u>not</u> specifically the focus of this evaluation since those activities will cease when the site is closed. However, use of the park along the Charles River as well as the Charles River itself are evaluated (see Subsection 6.3.2). The future use of the park and river were assumed to be more intense than present use (i.e., people frequent the area more often). In addition, future use of the site includes potential residential use of the site, which is assumed to be representative of present residential on-site use.

The second scope issue involves the use of groundwater. As discussed earlier in Section 4, groundwater in the area is not currently used for drinking water purposes nor is likely to be used in the future. Therefore, human exposures to groundwater as a drinking water source for the area are not evaluated in this risk assessment. However, possible incidental exposures to groundwater by other pathways are discussed in the exposure assessment section of this report.

Potential risks to ecological receptors are evaluated in Section 7 of this report.

6.1.3 ORGANIZATION

This baseline risk assessment consists of six subsections, including this introductory section. Subsection 6.2 summarizes the data evaluation and details of the selection of chemicals of potential concern. Subsection 6.3 summarizes the exposure assessment, including the identification of potentially exposed populations and evaluation of potential future exposure pathways. The exposure assessment also provides estimates of environmental concentrations of contaminants at exposure points and contaminant intakes for specific pathways. The Toxicity Assessment, Subsection 6.4, summarizes the carcinogenic and noncarcinogenic health effects related to the chemicals of potential concern. Subsection 6.5, Risk Characterization, combines the results of the exposure and toxicity assessments to characterize the potential for adverse health effects. Subsection 6.6 is an evaluation of the uncertainties related to this risk assessment.

This risk assessment is supported by six appendices. Appendix N contains a summary of frequency of detection, range of detected chemical and radiological concentrations and range of achieved detection limits in soil, sediment, and surface water. Appendix O contains exposure point concentration calculations for chemical contaminants. Appendix P provides detailed calculations of exposure and risk (chemical). Appendix Q contains detailed calculations of exposure and risk (for radionuclides). Appendix R contains detailed toxicity profiles for those chemicals that are chemicals of potential concern at the MTL. Appendix T documents the elimination of several pathways from risk characterization.

6.2 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The environmental sampling and analysis data collected at or near the MTL site were evaluated to determine suitability for use in a human health risk assessment in accordance with EPA's (1989c) Risk Assessment Guidance for Superfund (RAGS) and the guidance for data useability (EPA, 1990a). There were two objectives to be met in this evaluation: (1) to ensure that only sampling results of acceptable quality are used in the risk assessment and (2) to identify those site-related chemicals of potential concern (posing a possible risk of adverse health effects to exposed humans) that most appropriately serve as the focus of the risk assessment. At this point in the risk assessment monitoring data are evaluated, but conclusions regarding possible health concerns are not drawn until later in the risk assessment process. Chemicals detected in site-related environmental samples include those present as a result of Army activities at the site, chemicals that could have been introduced from off-site sources and naturally occurring chemicals.

In order to meet the first objective, available sampling data were summarized and reviewed from a quality control perspective. To meet the second objective, chemicals of potential concern were selected from chemicals (including radionuclides) detected in soil, surface water and sediment. This selection procedure is described in the last portion of this subsection.

6.2.1 EVALUATION OF DATA QUALITY

6.2.1.1 Excluded and Included Samples

As previously described in Section 4, analyses of containers (sumps, tanks, cisterns, etc.) were conducted for the purpose of characterizing contents for disposal. These containers are inaccessible and human contact with them is highly unlikely. This issue is discussed further in the exposure assessment. Samples from sumps, tanks, cisterns, manholes, and pipes are judged not to be media contributing to substantive or significant human contact or exposure and were therefore not included in risk evaluations (see Appendix T).

All available monitoring data from Phase I and II RI field activities were considered for usability in the risk assessment. Some data collected in Phase I and analyzed by Meta Trace were considered unsuitable and were not utilized in risk quantification. The data from resampled soil locations were substituted for the Phase I (1988) data.

Several samples were located off the site and upgradient; these were not considered in the evaluation of chemicals of potential concern but were considered representative of background. The upstream river water samples were SW-2, SW-3, SW-18, SW-19 and SW-20. The upstream sediment samples were SD-2, SD-3, SD-18, SD-19 and SD-20. The surface and subsurface soil samples that were considered background were those soil samples from locations 01SB-3, BKSB1 through BKSB4, GRSB-3, 01SS-1, 02SS-1 and 03SS-3. Three soil borings analyzed when drilling MW9, MW10, and MW13 were also considered background soil (see Subsection 4.3.1).

Monitoring data results for samples considered site-related and background data are summarized in Appendix N, Tables N-1 through N-8.

6.2.1.2 Laboratory Analytical Methods

In general, EPA analytical methods and USATHAMA-certified methods (or their equivalents) were used to perform chemical analyses of samples collected from the MTL site. These analytical results were evaluated for their suitability in the risk assessment.

In some cases, multiple methods were used to generate analytical data for a specific analyte in a specific sample. The following procedures were used to arrive at a concentration value for an analyte when multiple methods were reported in laboratory results:

- When all results were reported as less than/not detected (LT/ND), the lowest (most sensitive) value was chosen. Implicit in this decision was the assumption that chemical concentrations were the same for all aliquots.
- When combinations of detected and nondetected concentrations were reported, the detected value was selected. If there were multiple detected values, the average of the detected concentrations was used. The basis for this decision was the conservative assumption that the detected value(s) truly represented the sample concentration.
- When both values were reported as detected concentrations, they were averaged. The basis of this decision was the assumption that the arithmetic average best represented the concentration in the medium for that sample location.

Quality control requirements include the collection of duplicate samples in the sampling program. In those cases where a sample and its corresponding duplicates were analyzed by the same method and operating conditions, the reported values for the duplicate pairs were averaged and that average value was used to represent the medium concentration for that sampling location.

6.2.1.3 Laboratory Qualifier Codes

When environmental samples are analyzed by laboratories a quality control system is followed to ensure the data user that the results meet a required level of quality. These quality control indicators (called qualifiers or flagging codes) are evaluated by the risk assessor to determine if the data are acceptable for use in estimating risks. Standard USATHAMA Installation Restoration Data Management Information System (IRDMIS) flagging codes were attached to MTL analytical results by the laboratory to communicate laboratory quality conditions associated with measurements. Seven, single-letter flagging codes were encountered in the MTL data set.

D - Duplicate sample or test name.

- K Missed holding times for extraction and preparation.
- L Missed holding time for analysis.
- R Analyte required for reporting purposes but not currently certified.
- S Results based on internal standard.
- U Analysis is unconfirmed.
- X Analyte recovery outside certified range but within acceptable limits.

The "U" flag was assigned when the initial analytical results were not confirmed during a confirmatory analysis. These "U" flags were only found in association with low preliminary detections of pesticides. Data associated with this flagging code were not used in the risk assessment. Data associated with all other flagging codes were considered suitable for the risk assessment (see Section 4.12).

6.2.2 SELECTION OF THE CHEMICALS OF POTENTIAL CONCERN

6.2.2.1 Elimination of Chemicals

For the MTL site six criteria were used for eliminating chemicals from consideration in this risk assessment: nondetection in all media, occurrence within the range of background concentrations, infrequent detection, nutritional essentiality, tentative identification (i.e., lack of certainty in the identification) and general water quality parameters (which are not specific chemicals). Each elimination decision is discussed below.

Nondetection

Any chemical not detected in any medium was eliminated as a chemical of potential concern since there is no evidence that the chemical is present at the site. A total of 113 chemicals were eliminated on this basis (Table 6-1).

Elimination of these chemicals does, however, introduce some uncertainty into the risk assessment. Chemicals that are not detected are not necessarily absent from the sample, but may pose risk to human health at levels below those at which the analytical laboratory can reliably detect and measure.

Tentatively Identified Compounds

A number of tentatively identified compounds (TICs) were detected in site samples. Most TICs detected at the site are hydrocarbons, including unknown polycyclic hydrocarbons, unknown long chain hydracarbons, unknown long chain oxy hydrocarbons, and polynuclear aromatics with molecular weights of 192 and 216. The only individual compounds identified were benzo[e]pyrene and hexadecanoic acid. Since the chemical identities of these TICs are highly uncertain, the estimated concentration values can be imprecise by several orders of magnitude (EPA, 1989a), and there are no toxicity values available for the two individual compounds identified, none these compounds was selected for quantitative analysis. A qualitative discussion of the uncertainty introduced into the risk assessment by this decision is presented in Section 6.6.1.

Exclusion of Chemicals Based on Comparison to Background

Some of the chemicals detected on site occur naturally in soil, water and sediments and others are widely occurring anthropogenic chemicals. These chemicals may not be related to site activities and can be eliminated from risk characterization if they are present at levels consistent with background (MADEP, 1992). In order to determine whether site sample concentrations were consistent with background sample concentrations, the geometric means of background data were compared to the geometric means of site data, on a medium by medium basis. All soil samples from 0 to 12 feet for both background and site-related samples were used in the calculation of geometric means for soil. One-half the detection limit was used for nondetects in the calculation of geometric means for background and site-related samples in all media. Tables 6-2 through 6-4 summarize the results of such a comparison and the decision as to whether a chemical should be retained as a chemical of potential concern. The decision to eliminate a particular chemical was made according to the following rationales:

- If the geometric mean of on site samples was less than the geometric mean in background samples and the maximum hit was similar in both data sets, the chemical was eliminated from risk quantifications in that medium.
- If the site geometric mean was slightly higher than the background geometric mean and the maximum site hit was within generally observed background concentrations in Massachusetts the chemical was eliminated from risk quantifications in that medium.

Application of these criteria resulted in the elimination of aluminum, arsenic, barium, bis(2-ethylhexyl)phthalate, manganese, 2-methylnaphthalene, tin and vanadium from all media. In addition, acenaphthylene and fluorene were eliminated from soil risk characterizations, but were retained as chemicals of potential concern in Charles River sediments. Although beryllium and chromium could be eliminated as chemicals of potential concern based on background comparisons, they were retained due to historical use of these chemicals on site.

Infrequent Detection

Risk assessment guidance suggests that the number of chemicals evaluated at a site can be reduced by eliminating chemicals that are infrequently detected (EPA, 1989a; MADEP, 1992). In general, the application of this elimination step is somewhat subjective regarding the percentage criterion. A commonly selected criterion is the occurrence of the contaminant in less than 5% of the site samples on a medium by medium basis. The tables in Appendix N provide information on detection frequency for each chemical in each sampled medium. These frequencies are based on detects per total number of samples analyzed in each medium. However, for screening chemicals for elimination from further evaluation in the risk assessment, it is appropriate to consider samples from all depths of a soil boring as one sampling location and calculate

frequency based on detects per number of sampling locations. This criterion was used for the MTL site. Any chemical detected at 5% or less of site sampling locations was further evaluated to ensure that the detected values were not very high nor clustered in a single area of the site. Chemicals eliminated by this procedure are listed in Table 6-5 with the detection frequency in soil, surface water and sediments. The elimination of these 14 chemicals allows the risk assessment to focus on those chemicals which have the greatest impact on risk estimates.

Nutritional Essentiality

Some metals detected at the site are considered essential human nutrients (calcium, copper, iron, magnesium, manganese, potassium, sodium and zinc) and are beneficial at moderate levels. Hence, essential nutrients detected at the site are not likely to be of concern to human health. The evaluation of essential nutrients was performed only with respect to soil, judged to be a significant potential exposure medium. The maximum detected concentrations of these metals in surface soil were used for screening purposes to estimate a daily intake of these elements, based on assumed ingestion of 120 mg/day of soil (EPA, 1989c). If the estimated intake of a chemical (mg/day) did not exceed the Recommended Dietary Allowance (RDA) for an adult (>18 years old) (NAS, 1989), the chemical was eliminated as a potential source of concern for this site. Calcium, copper, iron, magnesium, potassium, sodium, and zinc were eliminated as potential contaminants of concern (see Table 6-6).

Substances Represented by Classes of Compounds

A number of classes of compounds and physical effects were also deleted because toxicity data specific to these parameters or compound classes are either not available, or are available for individual chemicals within these classes. Specific compounds detected within each class (e.g., PAHs such as naphthalene and anthracene) were individually evaluated in the risk assessment. The exclusions included:

- Alkanes
- Bichlorobenzene-nonspecific
- Hexachlorobiphenyls
- Pentachlorobiphenyls
- Polynuclear Aromatic Hydrocarbons
- Tetrachlorobiphenyls
- Trichlorobiphenyls
- Gross Alpha (Physical Effect)
- Gross Beta (Physical Effect)

General water quality parameters were also deleted since they are not relevant to risk estimates:

6-7

- Total hardness
- Total organic carbon
- pH

6.2.2.2 Summary of Chemicals of Potential Concern

Table 6-7 summarizes the chemicals and radionuclides selected as chemicals of potential concern for the MTL site. Appendix N provides the analytical sampling results for all the chemicals at locations on site or potentially impacted by site contaminants. The results include frequencies of detection, ranges of detected concentrations, and ranges of "ND/LT" values (i.e., detection limits).

6.3 EXPOSURE ASSESSMENT

Exposure is defined as the contact between an individual and a chemical of potential concern. The magnitude of this contact is determined by estimating how much of the chemical is available for absorption at one of the body's exchange boundaries (i.e., the intestinal tract, the lungs, or the skin) during a specified period of time. Determining the type and magnitude of this exposure to the chemicals of potential concern is the objective of an exposure assessment. This section identifies the types of possible future exposures at the MTL site and estimates the potential magnitude, duration, and frequencies of exposure for those exposure pathways.

6.3.1 CHARACTERIZATION OF THE EXPOSURE SETTING

Section 3 discussed the physical characteristics of the MTL site with regard to topography, land use, climate, surface hydrology, and hydrogeology. Some of this information is pertinent to the risk assessment and is summarized in the following subsections.

6.3.1.1 Physical Setting

The MTL is located on the eastern end of Watertown, Massachusetts about five miles west of downtown Boston and within the greater Boston metropolitan area (see Figure 1-1). The active facility is bordered by Arsenal Street to the north, by North Beacon Street to the south, commercial property to the west and a park to the east. It is in a generally flat area, decreasing in elevation from approximately 36 feet at the north to approximately 2.4 feet (river elevation) at the south. Almost the entire MTL facility is situated on a low bluff, about 20 to 30 feet above the river elevation. The MTL site includes 30 buildings, about ten of them major structures, used for Army research, development, testing, and manufacturing. The Commonwealth of Massachusetts has limited control over the 11 acres between North Beacon Street and the Charles River, which is used as a public park and picnic area and is leased in part for a private yacht club marina. Sections 1 and 3 contain additional information on physical conditions at the site.

Climate and Meteorology

The average annual wind speed for 1987 was 20.0 km/h (12.4 mph). Winds of 48.3 km/h (30 mph) or higher can be expected at least one day every month. The most

prevalent wind direction is from the southwest except in the months of December through March, when northwesterly winds prevail.

The freeze-free period is typically between early April and early November. Subsection 3.2 contains additional information on climatic conditions.

Geologic Setting

The MTL is located in the north central portion of the Boston Basin. Topographically this basin is bounded by low hills to the north, west and south. The east margin of the basin lies beneath Massachusetts Bay.

Hydrology

Surface water runoff and natural drainage at MTL have been greatly influenced by construction modifications to the natural land surface, in particular buildings, roads, parking lots and fill areas. There are no known streams or other natural drainages to the Charles River in the vicinity of the site. Current surface drainage is predominantly to the storm sewer system that discharges through outfalls into the river. Some natural runoff probably follows topography toward the river. Surface drainage flows into catch basins and from there into storm sewers constructed of vitrified clay, reinforced concrete and corrugated metal pipe. The catch basins tend to accumulate sediment. Natural recharge through seepage is probably quite minimal at the MTL site because of the number of structures and paved areas.

Groundwater elevation contours for the uppermost aquifer have been estimated based on water level measurements in shallow monitoring wells and borings (Section 3.6). These contours indicate that groundwater flow is generally to the south, toward the Charles River. In the northeast corner of the site, flow is initially to the southeast, then swings to the south (see Figures 3.9 and 3.10). Subsection 3.6 discusses the hydrogeology of the site in detail. Drinking water in the Watertown area is supplied by a system of reservoirs in the area (including the Quabbin Reservoir in Ware, Massachusetts). Watertown is a member community of the Massachusetts Water Resources Authority (MWRA).

Vegetation

Despite continued development, a diversity of trees exists at MTL as a result of landscaping activities in the 19th century. Young trees and shrubs are found in the northern portion of MTL, where land development has restricted vegetation. Trees along the southern boundary, where less development has occurred, have provided erosion control where the land slopes sharply towards North Beacon Street. Thus, there is little surface runoff even in this area.

Those areas of MTL soil not protected by trees or shrubs and not covered by buildings or pavement are densely vegetated with grasses. Thus, at present, release of fugitive

dust from the soil through wind erosion is minimal. Additional information on site vegetation is provided in Section 7 - Environmental Evaluation.

The Charles River Near MTL

The Charles is a Class B river (Commonwealth of Massachusetts classification) that is designated as suitable for bathing and recreational purposes, public water supply with treatment, fish and wildlife habitat and certain agricultural and industrial uses. Fifteen species of fish inhabit the river in the vicinity of the MTL, including sunfish, carp and alewives (EG&G, 1989; Weston, 1991).

6.3.1.2 Potentially Exposed Populations

Current Populations

The facility currently employs approximately 500 personnel. As of January 1989 there was a resident population at the site of 21 (EG&G, 1989).

In 1989, a total of 26,279 people lived within a one-mile radius of the MTL and 98,990 between one and two miles (EG&G, 1989).

The 55 acres immediately to the east of the present MTL facility were part of the Watertown Arsenal prior to 1968. This area now accommodates a park and a condominium complex; commercial and light industrial properties lie to the south, between North Beacon Street and the Charles River (EG&G, 1989). A yacht club marina and a park lie to the south of MTL between the MTL site and the Charles River.

Other off-site populations potentially affected by contaminant releases from the site could be persons wading or swimming in the river along the waterfront park or using the park for other recreational activities (e.g., picnicking), yacht club users at the marina, and consumers of fish caught in the Charles River (anglers and their families). The present numbers of these two sub-populations could not be quantified.

Future Populations

Based on the "Highest and Best Use Study" (Dunn, 1990), several hypothetical future resident population scenarios -- or mixtures of these with Class B office, research and development, light industrial, and limited neighborhood retail use scenarios -- are conceivable for the area available for development. Based on this information future populations could include residents on site for most of the time and worker populations who could spend somewhat less time on site (i.e., a 40-hour work week). Estimates of the likely numbers of these populations were not identified.

Current use of the recreational facilities between the MTL site and the Charles River is expected to continue in the future. There is some possibility that the park could be

upgraded to include a beach and/or playground equipment. However, no information regarding plans of this nature were identified.

6.3.2 <u>IDENTIFICATION AND ANALYSIS OF COMPLETE EXPOSURE</u> PATHWAYS

An exposure pathway describes the movement of a chemical from a source to the point where an individual (the "receptor") comes in contact with that chemical. A complete exposure pathway consists of the following:

- A source and mechanism of chemical release
- A transport medium
- A point of potential contact with the contaminated medium
- An exposure route at the contact point
- A potentially exposed population

In general, a complete pathway contains all these elements. In some instances, the source is also the exposure point and there is no release or transport involved. If a pathway is not complete, there is no exposure and risk cannot be characterized.

The information available for the MTL site was evaluated to determine which exposure pathways could be complete from a future use perspective. To illustrate the exposure pathways from sources to receptors, a conceptual site model was developed and is illustrated in Figure 6-1. The elements of this model are described in more detail below. All possible and reasonable exposure pathways are first identified and evaluated for completeness; exposure pathways are then selected for quantification. From this, an exposure profile is developed for each likely receptor or group of receptors, which includes all likely exposure-related activities.

Identifying complete exposure pathways involves not only characterizing site features but also taking into consideration relevant physicochemical properties of the site contaminants. Sixty-three chemicals and radionuclides have been selected as contaminants of potential concern at this site. Predicting their fate and transport from their source at the MTL site to receptors at an exposure point on a case-by-case basis is difficult, involving estimates of properties or use of default values of questionable accuracy. Certain assumptions regarding fate and transport processes are made in the following pathway analyses. These will be explained and examined in the subsection on uncertainty. Additional detail on fate and transport mechanisms was provided in Section 5.

6.3.2.1 <u>Identification of Exposure Pathways</u>

On-Site Sources, Release Mechanisms and Transport Media

Research, development and manufacturing were conducted at the MTL site. Laboratory or production chemicals could have been released and subsequently migrated to other areas on or off site. These chemicals include solvents, fuel components, and inorganic compounds. In addition, it is known that pesticides were used in certain areas of the site and it is suspected that PCBs leaked from electrical transformers in particular areas. Some of these contaminants are moderately mobile and some like the PCBs and PAHs are relatively immobile. Thus it is possible that, over periods of years, these releases left contamination residues in surface soil and surface runoff (and associated sediment) that was conducted to the Charles River by means of the storm sewer system. Although some releases could have passed readily through site soils to groundwater, it does not appear that most soil contaminants are migrating to groundwater (Subsection 5.2.2). Building debris and, possibly, ash were used as fill to raise the land above the Charles River flood plain. These too could have been contaminated.

Ground surfaces at the MTL site are nearly completely covered by buildings, pavement or vegetation; there are few bare spots. For this reason, the suspension of soil particulates through wind erosion (fugitive dust emission) was eliminated as a significant contaminant release mechanism. It is possible, however, that future development of the site (i.e., new construction) could generate dust during excavation and grading activities.

At a number of locations within the MTL site, it is possible that construction of new buildings could also result in excavation of soil from as deep as 12 feet. This soil could be well mixed and distributed over the surface; thus risk could occur from the contaminants at an average concentration for the top 12 feet.

Produce (vegetables) grown by future on-site residents, constituting part of their diet, could potentially accumulate certain contaminants which are taken up by plants grown in contaminated soil.

The groundwater in this area is not utilized for drinking water or in any other way, nor is likely to be used in the foreseeable future. This assumption is supported by the availability of potable water from the reservoir system previously described and the highly urban land use. Although use of groundwater outside the MWRA water system is not strictly prohibited, potable use is strongly discouraged by the local health department. Construction workers could possibly be exposed to contaminants in groundwater by dermal contact during excavation activities. This incidental exposure would only occur if the water table were reached during digging for foundations, utility lines, etc. A screening calculation indicates that the risk from this pathway is not significant (see Appendix T). Another release mechanism involving groundwater might be the migration of volatile compounds in groundwater through the soil and through basement walls. Again, the low levels of volatiles detected in groundwater and the absence of such volatiles in soils leads to the conclusion that this pathway is not

significant. Thus, all forms of contact with groundwater were eliminated as reasonable exposure routes. The most plausible significance of groundwater contamination is the potential for contaminating the Charles River. This, however, is unlikely in view of the large dilution of inflowing groundwater by the river. As mentioned earlier, the site contains a number of sewers, cisterns, drains, etc. which may contain site-related contaminants. These structures are, however, relatively inaccessible to future residential or occupational receptors. Appendix T contains a listing of each of these and provides rationales for why exposure potential is considered trivial.

Wipe samples collected during the Phase II RI indicate that surface contamination is present on the walls inside buildings at MTL. There is no generally accepted methodology for the quantification of risks from exposures to indoor surface contamination. Appendix T presents information regarding the basis for this conclusion.

Off-Site Sources, Release Mechanisms and Transport Media

Suspended solids could be carried by surface runoff via the storm sewer system to the shore and Charles River bottom at or near the MTL. As a Class B inland waterway, the Charles River near the MTL is considered fit for bathing, recreational purposes and fish and wildlife habitat. The park along the river does not currently contain a bathing beach area although one could be developed in the future.

During swimming activities people come in contact with both water and sediments. Persons using the river park could also come in contact with the soils during recreational activities. Users of the yacht club marina along the river could occasionally enter the water, but not for extended periods or to swim regularly, nor would they regularly come in contact with soil there. Future development in the park is unlikely to involve subsurface excavation.

Contaminants in Charles River water and associated sediments could bioaccumulate in aquatic biota (e.g., fish), which in turn might be part of the human diet. The potential for contaminants to bioaccumulate in fish can be estimated from their concentrations in the water via bioconcentration factors (BCFs). It should be noted that a BCF-based calculation does not take into account bioaccumulation of contaminants in fish through ingestion of contaminated sediment or organisms lower in the food chain.

Exposure Points

An exposure point is defined as that point where a human can come in contact with a contaminated medium. The contaminated source, transport medium or release point itself can also be an exposure point (e.g., contaminated surface soil). Exposure points identified for the MTL site include:

- · Site and park surface soil
- Site subsoil
- Charles River surface water and sediment

- Site-grown garden vegetables
- Charles River fish

Four major reuse zones were identified by the Watertown Arsenal Reuse Study in May, 1993 as the most likely future uses of the site (see Figure 6-2). Although these zones were designated for particular reuses it is possible that other reuses could be considered. To provide a range of possible reuses, exposures were evaluated at each of the four zones, as follows:

- Zone 1 Sampling units 1 and 4 for future construction of buildings resulting in commercial or residential exposures;
- Zone 2 Sampling units 2, 5, 6, 7, 8, 10, 12, part of 13, and 14 for future commercial or residential exposures;
- Zone 3 Sampling units 3, 9, and 11 for future commercial or residential exposure;
- Zone 4 Sampling units 13, 15, and 16 for construction of new homes, future residential exposure in these homes or playground/park use of the area.

Although the reuse plan was changed in November, 1993 by combining Zones 1 and 2 into a single zone, the four zone model was retained for risk assessment purposes. This change is not expected to have a significant effect on risk estimates developed in this report.

Exposure Routes

Human populations can be exposed to contaminants by the following four routes: (1) ingestion of contaminated media, (2) inhalation of contaminated media, (3) dermal contact with contaminated media, and (4) external exposure to radiation.

Based on the nature of contamination and the anticipated activities at the exposure points, exposure routes identified for the MTL site include the following:

- Ingestion of and dermal contact with soils, surface water and sediments.
- Ingestion of contaminated garden produce or fish.
- Inhalation of resuspended particulates during construction activities.
- External exposure to radiation released from radionuclides in soils.
- Inhalation or ingestion of surface contamination within buildings.

Complete Exposure Pathway Analysis

The exposure pathways judged complete for hypothetical future land uses are listed in Tables 6-8 and 6-9. Potential pathways that are judged to be incomplete (e.g., no exposure point and/or route by which contact could occur) are not quantified. From all the complete exposure pathways at the site, some pathways were eliminated for quantitative analysis for the reasons listed below.

Inhalation exposures to VOCs in soil or surface water were not quantified since there does not appear to be a major source of these chemicals in the soils. Likewise there does not appear to be a potential for inhalation exposures to soil particulates suspended by wind erosion except during construction activities. This pathway is generally of concern only when large areas of bare soil are disturbed by wind or frequent vehicular traffic. This type of scenario could occur if new buildings were constructed in the future. Construction workers would then be more exposed (than nearby residents) during this activity since they would be in closer proximity to the generated dust.

For construction or commercial workers the soil dermal pathway presents a very low exposure potential since workers generally protect most skin areas with clothing. Therefore, dermal exposures to this population were not quantified.

Appendix T presents information regarding the elimination of other pathways from quantification.

Development of Exposure Profiles

Total exposure to a single individual can include exposures by several complete pathways. The following discussion develops an exposure profile for each likely group of receptors that may use the site in the future.

Future residents (adults and children) in Zone 1 could either live in existing buildings, or in newly constructed residences in these areas. In Zone 4 new residences could be constructed. The residents in existing buildings are exposed only to surface soils (0 to 2 feet). Residents in new housing are exposed to soils from 0 to 12 feet deep, since these subsurface soils may be excavated during building construction. Residents in Zones 1 and 4 are also assumed to plant a vegetable garden, since space might be available (there is currently a garden in Zone 4). These residents are expected to use the river park facilities and therefore could be exposed to river water and sediment and park soil during recreational activities.

The residents in Zones 2 or 3 are assumed to live in existing buildings with no new construction. Thus, they are exposed to surface soils. They are assumed not to plant a vegetable garden, since the buildings are close together and there is minimal space available for growing produce. Like the residents in Zones 1 and 4, these receptors would use the river park for recreation.

The construction worker is only exposed for a brief period (one year) in Zones 1 and 4 where new construction would potentially occur.

The commercial worker in Zones 1, 2, and 3 is assumed to work inside an existing building. The only exposures to this receptor are those associated with surficial soil transported into the existing buildings or from release of contamination on building surfaces within those buildings.

The Zone 4 park visitor is assumed to be a resident in Zone 1, 2 or 3 or a nearby off site resident who visits the area on a regular basis, if this zone is not developed as a residential area. It is assumed that any type of recreational activity which involves exposure to soil could occur. Exposures at this area are also included in residential exposures at Zones 1, 2, or 3 to assess total site risk.

There is the potential for any future resident in an existing building to be exposed to surface contamination. As stated earlier, the uncertainty involved in quantifying these pathways precludes quantification.

Table 6-10 summarizes the populations at MTL who are most likely to be exposed to site contamination once the MTL is closed, the exposure points at which they are likely to be exposed, activities which lead to exposure, the contaminated media to which they could be exposed and the potential routes of exposure. These are the populations and exposure pathways selected for quantification at MTL because they are reasonably foreseeable exposure scenarios for the future use of the site.

6.3.3 QUANTIFICATION OF EXPOSURE

The last step in the exposure assessment process is the calculation of an average daily intake of the chemicals of potential concern. The intake is an approximation of the exposure expressed in terms of the contaminant mass at the body exchange boundary per unit body weight per day (mg/kg-day). To calculate intakes, the following general equation is used:

$$I = C \times (CR \times EFD/BW)(1/AT)$$
 (1)

where:

I = Intake; the average amount of the chemical at the body's exchange boundary (mg/kg-day).

C = Chemical concentration; the amount of a chemical that comes in contact with the body during the exposure period (e.g., mg/kg in soil or mg/L in water).

CR = Contact Rate; the amount of contaminated medium contacted per unit time or event (e.g., mg/day for soil).

EFD = Exposure Frequency and Duration; how long and how often exposure occurs. The EFD term is usually calculated from two terms, the exposure frequency, EF

(usually expressed in days/year) and the exposure duration, ED (usually expressed in years).

BW = Body Weight; the average body weight over the exposure period (kg).

AT = Averaging Time; the period over which exposure is averaged (days).

Many of the values selected are those that represent an average or mid-range of the possible valves that could be used. Thus, use of these values for the variables in this equation provide a realistic yet adequately conservative estimate of risk (MADEP, 1992; MDEQE, 1989). Since a degree of conservatism is employed in these risk calculations the estimates are not likely to underestimate true risk, but to provide some measure of protectiveness.

Quantification of exposure is undertaken in two stages: estimation of exposure point concentrations (the "C" term in the equation) and calculation of human intake factors (HIFs: the combined "CR," "EFD," "BW" and "AT" terms in the equation).

6.3.3.1 Estimation of Exposure Point Concentrations

An exposure point concentration is generally the arithmetic mean concentration of a chemical in a medium, averaged over the area in which exposure is expected to occur (MADEP, 1992). Although this concentration is not the maximum concentration that could potentially be contacted at any one time (with the exception noted below), it is regarded as a reasonable estimate of the concentration that is likely to be contacted over time. If the maximum detected value is less than the arithmetic mean (which can occur if there are many nondetects and some detection limits are higher than the detected values), the maximum detected value was selected as the exposure point concentration.

Calculation of exposure point concentrations involves (1) selecting samples from locations that represent exposure points and (2) analyzing available sampling data to estimate the mean concentration of each chemical at each exposure point.

Sampling data used in each exposure point concentration calculation are described below and summarized in Table 6-11.

The site has been divided into four exposure zones, based on potential likely future use of the site (Figure 6-2). A receptor in each of these zones would be exposed to surface soil around the existing buildings in a given zone. Exposure point concentrations were therefore calculated from all surficial soil samples in a given zone, assuming exposure would be equally likely at any location within a zone. Future exposure of residents to subsurface soil is also possible if building excavation were significant. The uppermost analyzed sample from each soil sampling locations (but from no more than two feet deep) was treated as a surface sample. Surficial soil exposure point concentrations were calculated for all four zones. Soil analyses to a depth of 12 feet were used to calculate separate exposure point concentrations for Zones 1 and 4 only, since excavation for new

construction is most likely at those locations. A surface soil exposure point concentration was calculated separately for the river park using only 0 to 2 foot sample results, since new construction is not anticipated at that location. Data are not available as to how these chemical concentrations could vary over time. Therefore, it was conservatively assumed that the measured concentrations remain constant over the exposure periods evaluated.

The same exposure point concentrations developed for surface soil contact in Zone 1 and subsurface soil in Zones 1 and 4 were also used for calculating exposure point concentrations in garden vegetables. For that calculation, literature values of soil-to-vegetable transfer coefficients were used, where available. These are available for most metals of concern (Baes et al., 1984). For most organic contaminants the relationship between octanol-water partition coefficient and soil-to-vegetation bioconcentration factor has been established (Travis and Arms, 1988). The methodology for calculating vegetable exposure point concentrations is described in more detail in Appendix O, Part A.

In order to evaluate exposures to soil particulates generated in future construction activities, the amount of respirable dust particles (PM_{10}) in air must be estimated. Since specifics regarding these future activities are unknown, it was assumed that the PM_{10} concentrations would be consistently present at the OSHA limit of 5 mg/m³ on days when excavation or grading occurred (OSHA 1992). Concentrations of contaminants in soil were multiplied by this factor in order to develop a respirable dust concentration in air.

The arithmetic mean for analyses of all the MTL-associated Charles River water samples (Table 6-11) was used to estimate contaminant concentrations in the local fish. The concentration of a given contaminant in fish was calculated as the product of each chemical-specific bioconcentration factor (BCF) and the average water concentration. These calculations are shown in Appendix O, Part B. In the case of swimmers who might ingest or be dermally exposed to surface water and sediment, only analyses of water samples closest to the park were used in exposure calculations. Developing any exposure point concentrations which involve river water are considerably uncertain given the fact that the river is a moving body of water subject to changes in flow and the variability in what could be entering the river from both MTL and other sources upriver. Nevertheless, the available sampling data were utilized and those concentrations were assumed to remain constant over time.

Some chemicals of potential concern were not detected in all media. For example, several chemicals of potential concern were detected only in soil; they were not present in surface water or sediments. Inclusion of these chemicals in risk quantification for a medium in which they had not been detected would overestimate risk. Therefore, a chemical not detected in any sample in a particular medium was not quantified for that medium. Other data adjustments included:

 All nondetect data results within a sample set were converted to one-half their detection limits before averaging (MADEP, 1992). Field duplicates (two samples from the same location) were combined by averaging the reported concentrations, using onehalf the reported detection limit if one of the samples was a nondetect.

Worksheets documenting exposure point concentrations are included in Appendix O, Part B.

6.3.3.2 Calculation of Human Intake Factors

In the general equation for calculating human intake (equation 1), the HIF incorporates the terms that describe exposure relative to human activity. The value of the HIF term in calculating chemical intakes depends on the specific exposure scenario being evaluated. An HIF value is calculated individually for each exposed population, for each medium, for each exposure route and for each exposure duration. In general, an HIF value is comprised of three terms:

- A contact rate term that describes the quantitative intake of a medium (e.g., mg of soil or L of water) by a person on a day when exposure occurs.
- A body weight term.
- A series of time correction factors that account for the fact that
 exposure may not occur every day during the time period of
 interest. These variables include exposure time (hours/day),
 exposure frequency (days/year), and exposure duration (years).
 These factors are divided by the period (in days) over which
 exposure is averaged.

Activity Patterns of Potentially Exposed Populations

Human intake factors are derived for the assumed populations for the exposure profiles (Table 6-10). A brief description of the assumed activity patterns for each of these populations is presented below:

<u>Site Residents</u>. These individuals are child and adult residents who live on site in any one of the zones and are home all day or for most of the day. Contact with yard soil results in exposure to soil contaminants by the ingestion and dermal routes both indoors and outdoors. These same residents in Zones 1 and 4 only are also assumed to consume their own garden produce as a fraction of their vegetable diet. Future residents can visit either the river park or the Zone 4 recreational area, if Zone 4 is not residentially developed.

Zone 4 Visitors. Zone 4 may be developed as a public area. It could be developed as a recreational area for local residents (either living on site or off site). It is assumed

that visitors to this area would engage in recreational activities such as ball-playing or picnicking which could involve oral and dermal exposure to surface soils.

River Park Visitors. The proximity of the river park to the site makes it likely that all ages of residents would use this area for a variety of recreational activities. Young children would be most likely to be involved in activities which would result in ingestion or dermal contact with soil. Older children and adults would be exposed to a lesser degree by these pathways. Both children and adults would be expected to use the river itself as part of their recreational activities. This would result in exposures to river water, sediment, and fish.

It is assumed that anglers share their catches with their families. This population is considered separately from the future residential MTL site population, but the risks are added to the future residential risks since future residents could consume fish from the river.

<u>Construction Workers</u>. These individuals are assumed to be adults who are engaged in building new structures on site. Since excavation and grading are dust-producing activities, exposure is assumed via both ingestion and inhalation.

<u>Commercial Workers</u>. These workers are assumed to be commercial or office workers in the buildings already existing on site. They may be exposed to contaminants in soil by ingestion during their daily activities.

Selection of Exposure Factors

The exposure factors selected for calculation of HIFs are in accordance with guidance provided by the MADEP (1992). The assumptions employed were chosen to represent the average exposure for the theoretically most exposed individual (MADEP, 1992). For residential and visitor populations, noncarcinogenic health effects were evaluated for age groups which represent the highest subchronic and chronic exposures, a child age 1 to 2 and a child age 1 to 8, respectively (MADEP, 1992). Carcinogenic risks were evaluated based on the adult whose period of exposure includes childhood. For worker populations, all evaluations are based on exposure only as an adult. Time-weight averaging was used to normalize intake rate to body weight over the period of exposure. The following values were used in the pathway-specific exposure calculations.

<u>Body Weight</u>. Assumed average body weights were 10.5 kg for the 1- to-2-year-old child, 16.8 kg for the 1- to-8-year-old child (14.6 kg for ages 1 to 5, 22.3 kg for ages 6 to 7), and 50.8 kg for ages 6 to 30, based on average body weights (MADEP, 1992). The average body weight of an adult worker is assumed to be 70 kg (EPA, 1989c).

Exposure Frequency. Residential exposure frequency is based on full-time residence, with 15 days per year spent away from home, resulting in a frequency of 350 days per year for activities which are likely to occur every day spent at home. This frequency was also assumed for ingestion of garden vegetables. For soil ingestion, exposure frequency was weighted based on the indoor/outdoor residential exposures assumed for

the Massachusetts climate - 153 days of exposure outdoors and 212 days indoors only. It is assumed that dermal exposure to soil occurs only during outdoor activities such as playing in soil (for children) or gardening-type activities (for adults) and that indoor exposures are trivial. Thus, it was conservatively assumed that dermal exposure to soil in this climate occurs 109 days per year (MADEP, 1992).

Park visitors are expected to use the park approximately once a week during the seven months of reasonably good weather in the area (28 days per year). Visitors to the Zone 4 recreation area are expected to visit twice a week (56 days per year), since this area would be more accessible to the future residential area. The national average for swimming is seven events per year (EPA, 1989c) and this value is assumed for this site.

Fishing in the Charles River is considered recreational. There is no evidence that the river supports subsistence fishing. As a very conservative estimate, it is assumed that an angler obtains one meal for his family for each day of fishing and fishes the river ten days per year.

Commercial workers are assumed to be exposed at the workplace 5 days a week, 50 weeks per year, for an exposure frequency of 250 days per year (EPA, 1991a).

Dust generating activities are estimated to occur 18 days (six days for foundation excavation, six days for backfilling and six days for grading) over a one-year new construction period. These assumptions are based on best professional judgment regarding what might be considered reasonable for the future development of the MTL.

Exposure Duration. An adult resident is assumed to be exposed for a period of 30 years, beginning in childhood (EPA, 1991a; MADEP, 1992). The subchronic and chronic exposure periods for a resident are assumed to be one year (age 1 to 2 years) and seven years (age 1 to 8 years), respectively (MADEP, 1992). Time-weighting may divide these periods into sub-periods, but the total exposure duration remains the same. Visiting the park or Zone 4 was assumed to occur over the same residential time frames, except that for the young child (age 1 to 2, subchronic exposure) the exposure duration was assumed to be the 28 weeks of reasonably good weather during that one year (0.54 year). A commercial worker was assumed to be exposed for 25 years (EPA, 1991a) and the construction worker was assumed to have a one-year exposure.

Exposure Time. It is assumed that the only time dependent exposure event consists of a half-hour (0.5 hour) of swimming in the river (EPA, 1992c).

Averaging Time. The averaging time is assumed equal to the exposure duration for subchronic and chronic (noncarcinogenic) hazards and 70 years for lifetime (carcinogenic) risks (EPA, 1989c).

<u>Ingestion of Soil</u>. Available data on soil and dust ingestion by humans under typical residential conditions indicate that most soil ingestion occurs by hand-to-mouth activity (cigarette smoking, nail-biting, finger wetting, etc.) and during meals (Hawley, 1985).

For children, mouthing of nonfood items is nearly universal during infancy and decreases with age (Sedman, 1989).

For residents, soil intake includes ingestion of soil while engaged in outdoor activities and ingestion of indoor dust, which is composed largely of outdoor soil (Hawley, 1985). It is estimated that on the days when outdoor activities occur, adults and older children ingest about 50 mg of soil per day and young children (age 1 to 6) ingest 100 mg per day (MADEP, 1992). On those days when ingestion is limited to indoor exposure alone, ingestion rates are much lower for young children and negligible for adults and older children (MADEP, 1992). On this basis, the calculation of chronic and lifetime HIF values for residents was time-weighted to incorporate a term for soil ingestion of 100 mg per day for ages 1 to 6 (5 years) during the estimated days per years (153) when outdoor activity can be expected and 50 mg per day for residents above the age of 6. During the 212 days per year when outdoor exposures are not expected to occur, soil ingestion was estimated only for the young child (MADEP, 1992). All soil ingestion was assumed to come from contaminated site soil, i.e., the fractional intake of contaminated soil was 1.0 for both surface soil and excavated subsurface soil.

There are few data to support soil ingestion rates during recreational activities. A small child could conceivably ingest as much soil during these activities as during residential activities. Therefore, a 100-mg/event soil ingestion rate for small children visiting the park was assumed. For older children and adults, a soil ingestion rate of 50 mg/event was assumed. This reflects the fact that adults are less likely than young children to ingest soil during recreational activities or while supervising young children while at the park. For residents, these ingestion rates were conservatively added to the ingestion rate at home.

For construction workers, a daily soil ingestion rate of 480 mg/event was assumed. The potential for soil ingestion increases when occupational activities bring the worker into direct contact with soil. Hawley (1985) suggests that outdoor-type yard activity could result in a soil ingestion rate of 480 mg/active day. Soil ingestion for commercial workers was assumed to be 50 mg/day in the workplace (EPA, 1991a).

<u>Dermal Contact with Soil and Sediment</u>. One parameter needed to calculate dermal contact with soil is the soil-to-skin adherence factor. A value of 0.51 mg/cm² was assumed (MADEP, 1992). This value was also assumed for sediment.

The second parameter required to calculate dermal intake is the fraction of the chemical that is absorbed (ABS) from the soil and sediment adhering to the skin. Data for this chemical-specific value is currently available only for two of the chemicals of potential concern at MTL, cadmium and PCB1260 (EPA, 1992c). For all other chemicals of potential concern values from MADEP (1992) were used. In the absence of a chemical-specific values, a default value was used, as follows: inorganics - 0.001; semi-volatiles and pesticides - 0.01; and volatile organics - 0.1.

The third parameter needed to calculate dermal intake is the exposed skin surface area per contact event. The values used for children were those suggested by MADEP

(1992); 2,500 cm² for a young child (1 to 2 years) and 3,700 cm² for an older child (1 to 8 years). For adults, 30% of the total body surface area (18,200) or 5,500 cm², was assumed to be exposed to soil (MDEQE, 1989). These values were assumed for both hypothetical future residents and park visitors for both soil and sediment exposures.

<u>Dermal Contact with Surface Water</u>. Estimates or default values for K_p , the chemical-specific permeability constant used to calculate dermal uptake of chemicals from water, are available for a number of chemicals (EPA, 1992c). For some chemicals of potential concern measured values were not available, and the K_p was calculated from other properties as suggested by EPA (1992c).

During a swimming event it is assumed that the entire body's skin surface is available for exposure. The values assumed were 5,130 cm² for the 1- to 2-year-old child, 7,120 cm² for the 1- to 8-year-old, and 18,200 cm² for the adult (MADEP, 1992; MDEQE, 1989). The value for the 1- to 8-year-old is the average of total body area for the years from 1 to 8.

<u>Ingestion of Sediments</u>. Swimming can cause river sediments to be resuspended and incidentally ingested along with surface water. No data were located on the amount of sediment likely to be ingested during this activity. Based on best professional judgment, a value of 50 mg/event was assumed for all swimmers.

<u>Ingestion of Surface Water</u>. Swimmers are assumed to ingest 50 mL of water per hour (EPA, 1989c).

Consumption Rate for Fish. It is assumed that each adult serving of fish weighs 8 oz (0.227 kg) (EPA, 1991a), and that a child's portion weighs half as much (4 oz or 0.114 kg).

<u>Ingestion of Homegrown Garden Vegetables</u>. Estimates of the rate of ingestion of homegrown vegetables vary considerably. The MADEP (1992) estimated that the ingestion rate for homegrown produce is 0.85 g/day for a 1- to 2-year-old, 1.16 g/day for a 1- to 8-year-old and 1.6 g/day for an adult. These values were assumed for the residential populations expected to have a vegetable garden at MTL.

Summary

Tables 6-12 through 6-23 present calculations of HIF terms for each assumed exposure scenario. The resulting HIF values are further summarized in Table 6-24.

Adjustments for Radionuclides

Since data for radionuclide concentrations and their associated toxicity values (slope factors) are expressed in terms of activity (i.e., pCi/L for water, pCi/g for soil and Risk/pCi for slope factors), it is necessary to adjust the HIF values previously described. For all HIF equations, intakes from radionuclides are calculated by using the same

exposure factors but not dividing by body weight or averaging time. The HIF values utilized in radiological risk calculations are summarized in Table 6-25.

Unlike other types of exposures to contaminants, external exposure to radiation produced by radionuclides does not entail exposure factors other than time duration. Intakes are calculated by multiplying the appropriate exposure point concentration times the appropriate exposure duration. These calculations are shown in the worksheets in Appendix Q.

Calculation of Average Daily Intakes

Average daily intakes were calculated using the exposure point concentrations (Appendix O (chemical) and Q (radiological)) and HIF terms derived as described above. Subchronic, chronic and lifetime intakes were calculated according to Equation 1. These calculations are summarized in Appendices P (chemical) and Q (radiological).

6.4 TOXICITY ASSESSMENT

The adverse health effects of a chemical generally depend upon the inherent toxicity of the compound and the level (intake), route (oral, inhalation, dermal or external) and duration (subchronic, chronic or lifetime) of exposure. This section summarizes available relevant information on the adverse health effects of chemicals of potential concern used in risk calculations.

More detailed toxicity summaries for each chemical of potential concern are provided in Appendix R.

6.4.1 NONCARCINOGENIC EFFECTS

When data permit, the EPA derives numeric values that are useful in quantifying the toxicity and carcinogenicity of a compound. For noncancer health effects, these values are termed References Doses (RfDs). A Reference Dose is a conservative estimate of the average daily dose of a chemical (mg chemical per kg body weight per day, or mg/kg-day) that is without risk of any noncancer health effects in humans, including sensitive subpopulations. An RfD is specific for a given exposure route (oral, inhalation) and for a given exposure period -- subchronic for two weeks to seven years, chronic for seven years to a lifetime (EPA, 1989c). An RfD is usually calculated from experimental data that identify the No-Observed-Adverse-Effect Level (NOAEL) or the Lowest-Observed-Adverse-Effect Level (LOAEL) in animals or humans. In order to provide a margin of safety, the RfD is taken to be the NOAEL or LOAEL divided by an appropriate uncertainty factor. Because the quality and quantity of toxicologic data available to support derivation of RfD values vary among chemicals, the EPA also provides an indication of the overall confidence associated with each RfD value. In general, the lower the confidence, the more conservative the EPA is in deriving the RfD.

Table 6-26 provides a brief summary of the critical noncarcinogenic effects of the chemicals of potential concern at this site and lists oral and inhalation RfDs for subchronic (RfD $_{\rm s}$) and chronic (RfD $_{\rm c}$) exposures and their confidence categories. For a number of the PAHs the dose-response data are too limited to support the derivation of an RfD. However, it is likely that these PAHs produce noncarcinogenic effects at doses similar to those of PAHs with a similar chemical structure. Therefore, RfD extrapolations were made for PAHs lacking RfD values, based on structural similarities with PAHs that have RfD values. These extrapolations include applying the RfD for acenaphthene to acenaphthylene, and applying the RfD for naphthalene to any other PAH.

6.4.2 CARCINOGENIC EFFECTS

For cancer, the numeric descriptors of carcinogenic potency are termed Slope Factors (SFs). These are route-specific, upper-bound estimates of the slope of the cancer doseresponse curve at low doses. (It is assumed the curve is linear in this region, and passes through the origin). The units of the SFs are (mg/kg-day)⁻¹. In addition, EPA assigns a cancer weight-of-evidence category to each chemical in order to reflect the overall confidence that the chemical is likely to cause cancer in humans. These categories and their meanings are summarized below.

Category	Meaning	Basis
A	Known human carcinogen	Sufficient evidence of increased cancer incidence in exposed humans.
B1	Probable human carcinogen	Limited evidence of carcinogenicity in humans.
B2	Probable human carcinogen	Sufficient evidence of increased cancer incidence in animals, but lack of data or insufficient data from humans.
C	Possible human carcinogen	Suggestive evidence of carcinogenicity in animals.
D	Cannot be evaluated	No evidence or inadequate evidence of cancer in animals or humans.
E	Evidence of noncar- cinogenicity for humans	No evidence of carcinogenicity in adequate studies.

Table 6-27 provides a brief summary of the characteristic cancer effects of chemicals of potential concern at this site and lists available oral and inhalation SFs and cancer weight-of-evidence categories. For all carcinogenic PAHs, except benzo(a)pyrene, the dose-response data are too limited to support the derivation of a slope factor. There

are two basic approaches by which the slope factor of benzo(a)pyrene can be applied to each carcinogenic PAH. By the first approach, all carcinogenic PAHs are assumed to be as potent as benzo(a)pyrene and therefore no adjustments are made to the slope factor. By the second approach, each carcinogenic PAH is assigned a toxicity equivalence factor (TEF) by which the slope factor of benzo(a)pyrene is multiplied. This former approach was utilized in this risk assessment.

Very little information is available regarding the specific chemical form(s) or valence(s) of the metals in environmental media at this site. Therefore, in order to be conservative, it is assumed that the metals are present in their most toxic forms. Thus, chromium is evaluated as if it were present in its hexavalent, and more toxic form.

All radionuclides are assigned a cancer weight-of-evidence category of A: known human carcinogen (EPA, 1992b). Lifetime cancer risk from radionuclides is estimated differently than for nonradiological chemicals. For example, an additional exposure pathway exists for radionuclides. The additional exposure pathway is referred to as external exposure, which pertains to exposure to external radiation from photon-emitting radionuclides distributed uniformly in a thick layer of soil. The units of the SFs for radionuclides are risk/pCi for oral and inhalation exposures, and risk/year per pCi soil for external exposures. Table 6-28 provides a list of available oral, inhalation, and external SFs.

6.4.3 DERMAL TOXICITY VALUES

Dermal toxicity values are based on an absorbed dose (rather than the exposed or administered dose), since dermal intakes are calculated as absorbed doses. The EPA has not as yet established any dermal toxicity values. Therefore, approximate values were derived by extrapolation from oral toxicity values. This was done by multiplying the oral subchronic or chronic RfD values by the oral absorption fraction (AF_c), and dividing the oral slope factor by the AF_o. Absorption fractions are chemical-specific values obtained from the toxicological studies including, if available, the studies used in determining toxicity values. This approach is based on the assumption that equal absorbed doses are equitoxic. Absorption fractions for inorganics developed by Owen (1990) are also used where specific data are not available. For all the organic chemicals of potential concern AF_o was assumed to be 1.0 (i.e., 100% oral absorption). This reflects the fact that most organic compounds are fairly well absorbed from the gastrointestinal tract. Such an approach, however, may not always be conservative since a lower AFo would result in a lower estimated dermal RfD or a higher slope factor. Risk, therefore, could be underestimated. No extrapolation from oral to dermal was performed for any PAHs, since these chemicals act at the point of contact (skin, stomach or lungs), so that inter-route extrapolation would be inappropriate.

In evaluating dermal exposures in water another toxicological parameter, the permeability constant (PC or K_p), is required. Permeability constants reflect the movement of a chemical across the skin into the bloodstream. Permeability constants have been determined experimentally for a limited number of chemicals. Permeability constants can also be estimated based on the molecular weight and log K_{ow} of each

chemical. Measured and calculated PC values are also summarized on the critical toxicity table in Appendix P.

In evaluating dermal exposure to soil the fraction of the applied dose which is absorbed (ABS) is required for each chemical. These values have been determined for only two of the chemicals of potential concern (cadmium and PCB 1260) (EPA, 1992). For other chemicals, default values recommended by MADEP were used, as follows: volatile organics - 0.1; semivolatiles and pesticides - 0.01 and inorganics - 0.001.

6.4.4 ADJUSTMENTS FOR ABSORPTION EFFICIENCY

There are circumstances in which adjustments to a toxicity value should be made to match the exposure estimate with the toxicity values (absorbed versus administered dose) or to account for different vehicles of exposure (e.g., food, water, soil). The adjustments made for dermal routes were described in the previous section. There were no adjustments made for medium of exposure after reviewing information on each chemical of potential concern either in the relevant ATSDR profile, available toxicological literature, or information in MADEP (1992), Appendix C. In all cases the relative absorption efficiency was nearly 1.0.

6.4.5 CHEMICALS WITH NO TOXICITY VALUES

Inspection of Tables 6-26 and 6-27 indicates that there are six chemicals (cobalt, dibenzofuran, isodrin, lead, sulfide and tetrazene) for which no toxicity values are available. Lead is evaluated using the Uptake-Biokinetic (UBK) model for child residents (see Section 6.5.3), and is retained in the exposure point concentration spreadsheets in order to provide the concentration values required for the model. Risks from the five remaining chemicals without toxicity values cannot be quantified and therefore do not appear in the risk calculation spreadsheets. There is some uncertainty, therefore, as to whether these chemicals are present at levels that could be a cause for concern.

6.5 RISK CHARACTERIZATION

Risk characterization integrates the results of the exposure and toxicity assessments into a quantitative description of potential cancer and noncancer risk estimates. The methods for risk characterization utilized in this baseline risk assessment are consistent with guidance provided in MADEP (1992) and EPA (1989c).

6.5.1 EVALUATION OF CARCINOGENIC RISKS

The risk of cancer from exposure to a chemical is described in terms of the probability that an individual exposed for his or her entire lifetime will develop cancer by age 70. This value is calculated from the daily intake averaged over a lifetime (DI_L) and the chemical-specific slope factor (SF), as follows:

Cancer Risk =
$$1 - \exp(-DI_L \cdot SF)$$
 (2)

In most cases (except where the product of DI_L and SF is greater than 0.01), cancer risk for a given carcinogen can be estimated more simply as:

Cancer Risk =
$$DI_L SF_L$$
 (3)

Slope factors have been derived by the EPA for a number of chemical carcinogens found at the MTL site, and each represents the incremental lifetime cancer risk per milligram of carcinogen per kilogram of body weight, assuming that the exposure occurs over a lifetime of 70 years. A slope factor is specific to the chemical and the route of exposure, i.e., inhalation or ingestion. The total cancer risk is the aggregate of the individual cancer risks, summed across all chemicals of potential concern and all exposure pathways that contribute to exposure of an individual in a given population.

In addition, slope factors have also been derived for the radionuclides. The ingestion and inhalation slope factors are best estimates of the lifetime excess cancer incidence per unit of activity. External exposure slope factors are best estimates of lifetime excess cancer risk for each year of exposure to photon-emitting radionuclides uniformly distributed in a thick layer of soil.

The daily intakes (averaged over a lifetime) resulting from exposure of populations assumed to be exposed to the carcinogens of potential concern at the MTL were estimated in Subsection 6.3.3; the slope factors for these carcinogens were provided in Subsection 6.4.2. From these, estimated cancer risks were calculated using Equation 2. The chemical- and medium-specific calculations are presented in Appendix P (chemical) and Q (radiological). Owing to the inherent uncertainty in cancer risk calculations, all risk values are reported to only one significant figure.

6.5.1.1 Summary of Chemical Cancer Risks

Typically, MADEP requires remediation at a site when total excess cancer risk levels to any population exceeds 1E-05 (one in one hundred thousand) (MADEP, 1992).

Tables 6-29 to 6-31 summarize total site carcinogenic risks to future adult residents. The exposure profile for these residents developed in the exposure assessment included exposures not only at the home but at both park areas (the river and the possible open area in Zone 4). Potential risks to hypothetical future residents exposed to chemical contaminants in site surface soil exceed 1E-05 for each potentially exposed population quantitatively evaluated and range from 7E-05 to 7E-04. Consumption of home-grown vegetables is the one pathway responsible for nearly all the calculated excess cancer risk from hypothetical exposures for these populations. Approximately half of the hypothetical risks are attributable to PAHs; several pesticides and PCBs contribute the

remainder. In general, risks to future residents exposed to site surface soil that has not been disturbed by excavation are slightly higher than estimated risks associated with site soil that could be excavated (surface and subsurface soil mixed) for new construction (Table 6-29).

Table 6-32 summarizes cancer risk estimates for assumed worker populations. If Zones 1, 2 or 3 were to be used commercially the commercial worker's exposure to surface soils in those areas could result in estimated cancer risks in the range of 3E-06 to 2E-05. The risk estimate for Zone 3 is above MADEP's risk management criteria. The risk estimates for a construction worker (Zone 1 or 4) covering a short-term exposure to contaminated soil were relatively low.

Table 6-33 summarizes risk estimates for recreational locations only (i.e., the river park or the open area in Zone 4). The highest estimated risk at the river park is posed by ingestion of soil by adults who could visit the park on a weekly basis during good weather. The estimated excess carcinogenic risk to this receptor is 1E-05. These risks are primarily due to PAHs detected in park soil. Swimmers in the river near the park could be exposed to both surface water and sediments. The estimated risks via these four pathways is 2E-06. Anglers and their families who are assumed to consume fish caught in the Charles River near MTL could be exposed to carcinogenic contaminants in fish tissue. The estimated excess carcinogenic risk calculated for this pathway is 5E-08. Visitors to the Zone 4 open area could incur an estimated cancer risk of 7E-06 again due mainly to PAHs detected in soils within that area.

6.5.1.2 Summary of Radiological Cancer Risks

Since both the units in which concentration is reported and the units in which the slope factors are expressed are different for radionuclides, calculations of radiological cancer risks were treated separately from calculation of chemical risks. For ingestion and inhalation exposure to radionuclides, the exposure medium concentration was multiplied by the pertinent HIF (Table 6-25) and finally by the slope factor in units of risk/pCi (Table 6-28) to obtain the risk number (unitless). For risk from external exposure to radiation, the soil concentration was multiplied by the exposure duration in years and then by the slope factor (units of risk/yr per pCi/g soil).

Radiological risk calculations are summarized in Table 6-34 to 6-36 for residential populations. Risk summaries for workers are presented in Appendix Q. Estimated radiological risks from the pathways evaluated ranged from 2E-07 to 7E-07. Therefore, it does not appear that radiation detected in soil, sediments, or surface water are present at levels of concern.

6.5.2 EVALUATION OF NONCARCINOGENIC EFFECTS

The potential for chemical noncarcinogenic effects is evaluated by comparing an intake over a specific time period with the RfD derived for a similar exposure period. This

comparison results in a hazard quotient, which provides a measure of the potential for adverse health effects other than cancer. For each individual contaminant, the daily intake averaged over the exposure period is divided by the RfD to derive the hazard quotient, i.e.,

$$HQ = DI/RfD$$
 (4)

where:

HQ = Hazard Quotient for subchronic (HQ_s) or chronic (HQ_c) exposure

DI = Daily Intake (mg/kg-day), either from subchronic (DI_S) or chronic (DI_C) exposure

RfD = Reference Dose (mg/kg-day), either for subchronic (RfD_S) or chronic (RfD_C) exposure

The RfD is the average daily dose that could be incurred without an appreciable risk of deleterious health effects. Reference doses have been derived for both chronic (greater than seven years) and subchronic (less than seven years) exposure periods. Potential exposures for the 1-to-2-year-old child and construction workers considered in this risk assessment are for periods of less than seven years; therefore, subchronic RfDs are considered. For other populations, the exposure periods are longer and chronic RfDs apply.

The estimated average daily intakes resulting from exposure to the contaminants of concern at the site were presented in Subsection 6.3.3 and the RfDs for these contaminants were identified in Table 6-26.

For an individual contaminant, a hazard quotient of less than one indicates a nonhazardous situation. The hazard quotients for all contaminants and pathways affecting a given population for the same exposure period are summed to determine a hazard index (HI), namely:

$$HI = HQ_1 + HQ_2 + HQ_3 + \dots HQ_i$$
 (5)

where:

HI = Hazard Index for either subchronic or chronic exposure

HQ₁ = Hazard Quotient for the first chemical

 $HQ_i = Hazard Quotient for the ith chemical$

If a screening level HI determined in this way is equal to or less than 1.0, it is presumed that noncarcinogenic health effects will not occur. If an HI exceeds 1.0, there is some possibility that noncarcinogenic effects could arise. In particular, this screening level approach assumes that all noncancer effects are additive. However, in some cases,

effects caused by one chemical on a particular tissue or organ are influenced by the effects of another chemical on another tissue or organ (EPA, 1989c). In instances where each contaminant-specific HQ is less than one, but the sum of HQs is greater than one, the major toxic effects of the individual contaminants are examined to determine the potential hazard associated with exposure to multiple contaminants. A hazard index of one is currently the MADEP-MCP risk limit for noncancer health effects.

Detailed calculations for noncarcinogenic effects are presented in Appendix P. Because of the uncertainty inherent in the calculation of HQ values, all HQs are reported to only one significant figure. Hazard indices estimated for noncancer health hazards for populations evaluated for the site are summarized in Tables 6-37 through 6-39.

Hazard indices exceed 1.0 only for ingestion of vegetables grown in site soils in Zone 4. Chlordane and heptachlor epoxide are the predominant chemicals which contribute to this estimate. Since these pesticides produce adverse effects on the same target organ (liver) by the oral route, it is not necessary to further segregate the HIs for chemicals which have similar types of toxic effects.

Table 6-40 summarizes hazard indices for the assumed worker populations. All estimated hazard indices are less than one indicating that there is not a concern for noncancer health effects for these assumed populations.

6.5.3 EVALUATION OF RISKS FROM EXPOSURE TO LEAD

Since there are no EPA-approved RfD values for lead, it is not possible to evaluate the noncancer risks of lead by calculation of a HQ or HI. An alternative approach is to estimate the likely effect of lead exposure on the concentration of lead in the blood (PbB). Several mathematical models have been developed for calculating the value of PbB as a function of environmental concentrations of lead (EPA, 1989f). Of these, the Uptake/Biokinetic (UBK) model has the greatest flexibility and has been most thoroughly validated, so it is selected for use here. The basic equation for calculating PbB with the UBK model is:

$$PbB = (\sum C_{i} \cdot I_{i} \cdot ABS_{i}) \cdot BKSF$$
 (6)

where:

 C_i = Concentration of lead in medium i (μ g/unit medium)

 I_i = Human intake of medium i (units medium/day)

ABS_i = Absorption fraction of lead from medium i (unitless)

BKSF = Biokinetic slope factor relating blood lead to absorbed dose. The units of BKSF are μ g/dL per μ g/day.

In general, the values of I, ABS and BKSF are all age dependent, and the value of PbB at any given age is a complex function of both current and past lead exposure levels.

It is commonly agreed that young children are more susceptible to the effects of lead than older children or adults, since (1) young children tend to have higher exposure levels (especially to soil), (2) young children have higher lead absorption rates, and (3) the nervous system of infants and young children is more sensitive to the neurological effects of lead.

The EPA has developed a computer program ("LEAD6") for calculating lead exposures and resulting PbB values in children age zero to six. This computer program, which utilizes the UBK model as its basis, was used to evaluate the effects of lead in environmental media on hypothetical future resident children at the MTL site. The calculations include lead exposure from all sources (including food, air, indoor paint and drinking water), and not just those specifically derived from the site (soil). Most input parameters (e.g., body weight, water intake, soil intake, breathing rate and lead intake from the diet) were taken to be the national average values suggested as defaults by the EPA. The site-specific geometric mean values calculated as described in Subsection 6.3.3 for the specific media (soil, vegetables) were used in the program.

Table 6-41 summarizes the results of the model output for each residential child population evaluated at the MTL. Although there is no universally agreed upon value of PbB that may be identified as "safe" for the effects of lead on children, the EPA has identified 10 μ g/dL as the level of concern for health effects in children that warrants avoidance (EPA, 1988c). Based on standard default and site-specific values shown in Table 6-41, geometric mean blood lead values are predicted to be between 1.9 and 2.5 μ g/dL for the hypothetical future on-site residential child population. It, therefore, appears that the lead is not a concern at this site.

It should be noted, however, that a hot spot for lead was detected at sample location O5SB-2 (north side of Building 656). The concentration of lead in this sample was 7,200 mg/kg. Soil samples in the adjacent sampling area were approximately 150 mg/kg. Since exposure is assumed to be random across Zone 3, this sample was equally weighted in determining the exposure point concentration inputted into the UBK model. If exposure were to be preferential at that location (i.e., all soil ingested by a receptor comes from that location) or any other location where higher lead concentrations were detected, then potential risk from lead would become unacceptable.

6.5.4 RISK CHARACTERIZATION SUMMARY

Exposure profiles were developed for two residential populations - adults and children - at four zones across the site. The residential profiles included exposures both at home and at site recreational areas. At each of these zones, carcinogenic risk estimates exceed 1E-05. Carcinogenic risks were highest at Zones 1 and 4, (2E-04 to 7E-04), where exposures to vegetables grown in contaminated soils were included. Carcinogenic risks in Zones 2 and 3 ranged from 7E-05 to 8E-05. The PAHs detected in soil are the primary contributors to this risk. Radiological carcinogenic risk estimates for residential populations were all within the acceptable range (i.e., less than 1E-05). Hazard indices calculated for resident children were all below 1E+00, except in Zone 4. At that location, an HI of 2E+00 (due to the presence of pesticides) was calculated for

the vegetable pathway. Although the UBK model predicted acceptable blood lead levels for children who might live in these zones, it was recognized that at least one location near Building 656 may require further evaluation if a child resident were to preferentially ingest soil from that area. This evaluation will take place as part of the FS.

Exposures profiles were also developed with the assumption that Zones 1, 2 and 3 could be developed commercially. There appears to be no health concern for workers in a commercial setting, exposed to soil from surrounding outdoor locations except in Zone 3 where the estimated cancer risk is 2E-05. Noncancer and radiological risk estimates are all within acceptable ranges.

There appears to be no health concern for construction workers who could be exposed to site contamination during future building type activities. Estimates for carcinogenic risk (chemical and radionuclide) are all within the acceptable risk range as are the hazard indices.

6.6 ASSESSMENT OF UNCERTAINTIES

A number of factors can introduce uncertainty into any exposure and risk estimate. This section attempts to identify those key factors and assumptions that contribute uncertainty to the evaluation of risks at the MTL site.

6.6.1 SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

Lists of target "analytes" (inorganic) and "compounds" (organic) have been developed by the EPA and by USATHAMA for the use of analytical laboratories. These lists cover the majority of pollutants found throughout the country, and particularly on military-related properties, but may not include all of the contaminants historically associated with a particular site. Therefore, not every conceivable chemical has been analyzed for in the environmental media at the MTL. This is not considered to be a major uncertainty which would contribute to a serious underestimation of risk.

Numerous TICs were detected in site samples (see Section 6.2.2.1). Risks from TICs were not evaluated because their identities were not considered sufficiently established. Most of the TICs were alkanes, alkenes or aromatic hydrocarbons. Alkanes and alkenes are not considered to be highly toxic, but aromatic hydrocarbons (particularly PAHs) could be toxic and/or carcinogenic to humans. Because the identities and concentration levels of the TICs are highly uncertain, it is not possible to provide any quantitative analysis of the health risk associated with exposure to these compounds. Thus, excluding these chemicals could lead to an underestimate of risk.

In this risk assessment, a number of substances were eliminated by several screening procedures. Elimination decisions were based on several criteria: nondetection, occurrence in background, infrequent detection and nutritional essentiality. Such a strategy is required to bring the more important contaminants into focus. Each screening step does, however, reduce risk estimates by some unknown amount, however small.

The decisions to remove chemicals not detected or infrequently detected are not likely to contribute to a serious underestimation of risk. Deletion of contaminants detected at low levels in less than 5% of the samples introduces slightly more uncertainty (per contaminant) than elimination of undetected contaminants.

Removal of chemicals occurring at higher levels in local background samples than at MTL carries with it the assumption that the local background samples are typical of the area, and thus reflect regional geochemistry or human activities. Elimination of chemicals detected at levels lower than background could introduce some underestimation of risks. On the other hand, retaining some chemicals which were also detected in background (e.g., beryllius and chromium) could contribute to overestimation of site-related risk.

Elimination of chemicals considered to be essential nutrients is not likely to introduce any major underestimation of risks. These chemicals are toxic only at very high levels and are also present at MTL at levels similar to background.

Several chemicals of potential concern were also detected at low levels in field blank and laboratory blank samples (see Section 4.12). No chemicals were deleted as chemicals of potential concern due to detection in blank samples. Thus, it is possible that reported levels of some chemicals could be due to laboratory contamination. However, none of these compounds contribute significantly to risk estimates for any receptor group.

Measurements of chlordane, alpha-chlordane and gamma-chlordane were carried through as separate chemicals for quantification of risks. It is uncertain whether this results in "double-counting" cancer risk and noncancer hazards from this group of compounds.

6.6.2 EXPOSURE ASSESSMENT

Total risk to an exposed individual from contaminants at a site is the sum of all complete exposure pathways. This risk assessment did not quantify every conceivable exposure pathway, only those that are reasonably foreseeable in the future and those that are considered nontrivial. It is believed that all major exposure pathways have been evaluated in this risk assessment.

The exposure point concentrations used for assessing risks are the arithmetic mean values, or the maximum detected value if the arithmetic mean value exceeds the

maximum detected value. Using the maximum value tends to bias the exposure point concentration toward the high side.

Although current analytical methods are generally adequate, detection limits for some toxic substances could be higher than desirable. To compensate for the uncertainty, a contaminant that has not been detected in a given sample, but has been detected elsewhere in that medium (e.g., soil) in the area for which an exposure point concentration was calculated, was considered to occur at half its detection limit. Where a contaminant was found in only a few samples, and at low concentrations, this assumption could lead to higher estimates of the average concentrations in the medium. On the other hand, a completely undetected target compound could occur widely at less than the detection limit, and its concentration would be considered zero everywhere. This contributes to uncertainty, in that it implies an underestimation of risk, but the contribution is likely to be small. In general, use of one-half the detection limit is more likely to result in some overestimation of risk.

Surface soil samples down to two feet below the surface were used to evaluate soil pathways. Since the near-surface soil is generally more contaminated than deeper soil, this tends to dilute soil concentrations more likely encountered by visitors or residents with cleaner material at lower depths. This is generally not considered to be a major source of uncertainty.

Dermal absorption from surface water is based on some rather uncertain assumptions. In particular, the permeability coefficients are either default values or based on an equation that contains its own set of uncertainties. It is unknown whether use of these methods overestimates or underestimates the risk. Likewise, absorption of contaminants from soil is a poorly understood phenomenon, whether contact is through the oral, dermal or inhalation route. The quantification of the process is likely to result in either over- or underestimates of exposure.

It is assumed that environmental media concentrations determined from sampling will remain at the same levels over the assumed periods of exposure. This assumption is likely to result in an overestimate of risk, since concentrations, especially of organic contaminants, can be expected to decline over the long term as natural fate and transport processes degrade, dilute or remove them from the site. This assumption is especially likely to result in highly inaccurate exposure estimates for those pathways involving river water. Sampling done as part of this RI only provided data for a particular time frame. Since these samples were collected from a moving river, the contaminant levels could have been over or underestimated.

When environmental data are lacking and models are used to calculate exposure point concentrations, uncertainty is generated both as a result of input assumptions that must be made and the limitations of the model itself. Modeling was used to estimate concentrations in three media: dust in air, fish, and vegetables. In order to estimate dust concentrations in air during future construction activities, a simplified assumption regarding possible PM₁₀ releases (i.e., not higher than an occupational standard) was used along with an assumption that those particles would be as contaminated as the

soil itself. These assumptions are extremely conservative and therefore the risk estimates for the hypothetical construction worker should be viewed as highly overestimated.

Models which estimate chemical concentrations in food (e.g., fish and vegetables) are based mainly on empirical relationships between physical and chemical properties of the contaminants and their observed uptake into plants or animals. These relationships are known to depend on a number of other variables including fish species, chemical form of the contaminant, feeding habits of the fish, plant type, soil conditions, etc. Extrapolation from laboratory conditions to site conditions is highly uncertain. The model used for vegetable concentration calculations, for instance, does not consider the metabolic fate of these contaminants within plant tissue. Likewise, models used in estimating exposure and risk through a food chain (i.e., fish) are also highly uncertain. Because the garden vegetable pathway contributes a substantial portion of the estimated risks at MTL, this is a source of considerable uncertainty.

There is no generally accepted methodology for characterizing potential risks from exposures to contaminated indoor surfaces. Information necessary to quantify such a pathway including resuspension factors, ventilation rates and the physical characteristics of the contamination itself are not available and any assumptions would be highly uncertain. The elimination of these pathways from total site risks does represent some underestimation of total risk to any receptor group living or working in an existing MTL building.

6.6.3 TOXICITY ASSESSMENT

The accuracy of risk estimates at a given intake directly depends on accurate toxicity values. For some chemicals of potential concern at the MTL site, toxicity values are not available by some routes. In some cases, in the absence of toxicity values, surrogate values were used (e.g., the oral chronic RfD for naphthalene and the SF for benzo(a)pyrene were adopted for various other PAHs). In other cases, the absence of these values could result in an underestimate of both noncancer and cancer health risks at this site, but is not possible to estimate the magnitude of this underestimate.

The predicted cancer risk due to chemical exposure is often based on cancer doseresponse data in animals. These data bases are often very limited. There is also a long-standing controversy in the scientific community as to the best way by which animal data should be extrapolated to humans. In general, the EPA follows a conservative procedure in the derivation of slope factors and reference doses, so risk estimates based on these values could be considerably higher than the true risk.

In developing slope factors it is assumed that exposure occurs over an entire lifetime. There is some uncertainty regarding how accurate slope factors are when used in estimating less-than-lifetime exposures like those assumed at the MTL site. The cancer risks calculated for construction workers in general are even less certain than those calculated for other populations. The method utilized in this risk assessment assumes cancer risks are simply proportional to total dose. Actual cancer risk to a person

exposed only for a brief period (one year) could be higher or lower depending on the detailed mechanism of carcinogenicity for each chemical.

Since there is no information on the fraction of total chromium that is CrVI at MTL, a conservative approach was taken and the toxicity values for CrVI were used to calculate risk from exposure to chromium in all MTL media. Since chromium is not contributing significantly to risk, it is apparent that even if all the chromium were present as CrVI (which is extremely unlikely), the presence of this chemical at MTL would not be of concern to human health at the exposure points evaluated.

In addition, all the PAHs were evaluated using the slope factor for benzo(a)pyrene (MADEP, 1992). In light of recent guidance (EPA, 1993) recommending the use of carcinogenic equivalency factors, using the slope factor for benzo(a)pyrene for the seven carcinogenic PAHs significantly overestimates risk from PAHs.

A related problem arises from the need to estimate dermal RfDs; this introduces a large degree of uncertainty, which is compounded by the nearly complete lack of information regarding absorption efficiencies, especially from soil adhering to the skin.

Lead is a contaminant of concern due to its ability to affect the nervous systems of fetuses or children, even at relatively low environmental levels. As presented in Subsection 6.5.3, the EPA has developed the "LEAD6" model (based on the UBK model) for estimating the likely change in the blood lead level that can be attributed to lead exposure at contaminated sites. Although this calculation is subject to a number of uncertainties, the predicted blood lead value at this site is not sufficiently high for lead in soil to be considered a matter of health concern at MTL except at some individual sampling locations.

6.6.4 RISK CHARACTERIZATION

The interactive effects of exposure to multiple chemicals are unpredictable; it is seldom known whether they will be synergistic, antagonistic or simply additive. Since exposure levels are low at MTL exposure points, it is likely that nonadditive effects will be minimal, and the toxicological uncertainty will be the sum of uncertainties related to the individual substances.

Section 7 Environmental Evaluation



ENVIRONMENTAL EVALUATION

The Environmental Evaluation will follow under separate cover.

Section 8 Conclusions and Recommendations



CONCLUSIONS AND RECOMMENDATIONS

The conclusions of the RI (including the RA) are presented in this section. Contamination was found to some degree in site media in various parts of the site. Most of the contamination is presently localized.

8.1 GEOPHYSICAL INVESTIGATION

A geophysical investigation using GPR and/or EM-31 was performed over portions of the site to assist in locating the following:

- Suspected USTs
- Fill areas
- Sewer line junctions

The parking lot between Buildings 37 and 131 was surveyed for the presence of a UST. Elevated conductivity readings, perhaps indicating buried metal, were detected between the fourth and seventh parking spaces in the northern end of the lot. The geophysical findings, together with soil boring and monitor well sampling results from sampling locations adjacent to and/or downgradient of the area in question, are indicative of the presence of a UST (see Subsections 4.3 and 4.4); however, it is recommended that the area be excavated to determine the actual presence of a UST.

The park along the Charles River, the on-site area north of North Beacon Street, and the areas south and west of Building 60 were surveyed for the presence of fill. More than half of the park area (primarily in the western portion) consists of disturbed soil or fill. Readings suggesting buried metal were detected in the northwestern and northeastern corners of the surveyed area of the park and in a small area in the center of the park. Areas north of North Beacon Street also contained disturbed soil or fill. High conductivity readings were detected near the propellant storage area and near the steep bank to the north, suggesting the presence of buried metals. Three disturbed areas were located near Building 60. The hillside and flat area southwest of the building appear to be all fill, and slag was observed on the hillside.

Visual inspection and GPR were used to revise the understanding of the piping configuration at five sewer junctions where discrepancies existed between site sewer maps and diagrams by ADL from the Phase 1 RI. Based on the current understanding of existing site maps, the ADL diagrams, and Phase 2 data, it can be concluded that some of the representations of sewer junctions on existing facility blueprints are incorrect. It is recommended that these maps be updated prior to facility closure.



8.2 SOIL INVESTIGATION

A soil sampling program was carried out to identify and delineate potential soil contamination throughout the facility. A facilitywide grid system (sampling on 300-ft centers) was utilized to collect data from locations not biased toward areas of suspected contamination. Additional borings were installed in areas where contamination had been identified in previous studies or near locations where hazardous or radioactive constituents may have been stored or used.

The 62 soil borings were advanced from ground surface to the water table using a continuous split spoon sampling technique. In addition, 30 surface soil samples were collected using stainless steel bowls and scoops. Approximately 200 soil samples were submitted for laboratory analysis for VOCs; SVOCs; cyanide; TAL metals; pesticides/PCBs; and radiological parameters, including gross alpha and beta; and uranium isotopes U-234, U-235, and U-238. In addition, selected soil samples collected from 18 of the soil borings were analyzed for TOC.

On-site sample results were compared to the MCP Method 1 Soil Standards for comparison purposes only. The RA used background concentrations based on sampling results from upgradient soil samples to assist in determining site-related compounds. For purposes of the risk assessment, the site was divided into four zones depending on possible or likely future use, plus the grassy area along the river (see Subsection 6.3.2.1). In addition, the RA considered both potential present and future use of the site. For soil, the following potential exposure pathways and exposure routes were evaluated:

- Future child and adult site residents ingestion of and dermal contact with yard soil and soil in the park areas. Ingestion of vegetables grown in contaminated soil was also evaluated. Exposure to excavated soil (0 to 12 ft deep) was considered where appropriate.
- Future commercial office workers soil ingestion.
- Future construction workers soil ingestion and inhalation of soil dust.

8.2.1 SAMPLING RESULTS

Soil samples collected from beneath concrete floors in Buildings 43, 311, and 312 showed elevated concentrations of SVOCs exceeding the MCP Soil Standards. Soils containing contaminant concentrations were generally located near the ground surface (between ground surface and 3 ft bgs). Contaminated soil beneath buildings is presently covered by concrete, and therefore, the likelihood of direct contact with the soil is remote and was not evaluated in the RA; however, exposure to soils to a depth of 12 ft was considered where excavation might occur for construction of residences.

Elevated concentrations of PAHs were detected in soil samples collected from borings completed in the grassy area between North Beacon Street and the Charles River. The



highest levels of PAHs were detected adjacent to Buildings 39, 227/60, and under the parking lot between Buildings 37 and 131. Analytical results showed very little evidence of radioactive isotope concentrations above background. No soil sample contained total uranium activity above the federally mandated maximum allowable total activity for DU of 35 pCi/g for soil (46FR52061).

Metals concentrations, primarily beryllium, were detected above MCP Soil Standards in shallow (less than 1 ft) soil samples collected from immediately outside Buildings 39, 43, 311, 313, and 656.

Noncarcinogenic pesticides were detected in surface soil samples, particularly in the grassy areas within Units 13, 14, 15, and 16.

Approximately 177 tons of soil contaminated by a leak of No.6 fuel oil on the north side of Building 227 were excavated by a contractor to MTL to a depth of 14 ft. When the excavation threatened the structural integrity of Building 227, it was discontinued. Further remediation of the area will be addressed in the FS.

8.2.2 RISK ASSESSMENT FOR EXPOSURE TO SOILS

Potential carcinogenic risks for hypothetic future resident adults and children due to soil exposure in each of the four zones exceeded 1 in 100,000. Where gardening was considered a potential future residential use (Zones 1 and 4), exposure through consumption of vegetables was the most significant exposure pathway, with risks exceeding 1 in 10,000. If Zone 4 were not further developed as a residential area and deeper soils (below 2 ft) were not excavated and spread on the surface, potential risks were calculated to be less than 1 in 100,000.

Potential carcinogenic risks in Zones 2 and 3 exceeded 1 in 100,000 primarily due to the potential ingestion of soil. Potential carcinogenic risks to future commercial workers in Zone 3 exceeded 1 in 100,000, primarily due to potential ingestion of soil. Potential risks for commercial workers in other zones, as well as future construction workers in Zone 1 or 4, would not exceed 1 in 100,000.

Results from soil borings installed adjacent to the functioning buildings at MTL indicated that PAHs and, to a lesser extent, Aroclor 1260 and dieldrin are responsible for most of the potential cancer risks. Because the cancer risks associated with PAHs are in excess of the risk allowed by Massachusetts and some chemicals also exceeded MADEP soil action levels, it is recommended that remediation of the soils in these areas be considered prior to facility transfer. It should also be noted, however, that most of the excess cancer risk is posed by consumption of vegetables grown on-site. Restrictions on growing vegetables in Zone 1 would suffice to reduce the risk to acceptable levels.

Analytical results showed very little evidence of radioactive isotope concentrations above background. RA results did not indicate any health risks in excess of 1 in 100,000 due to the presence of radioactive isotopes in the environment.



RA results indicated that elevated metals concentrations in soil do not pose a significant noncarcinogenic risk to humans (HQ less than 1.0). Noncarcinogenic HI values slightly exceeded 1.0 under potential residential exposure to excavated (surface and deep) soil in Zone 4 (HI = 2). This hazard index was primarily due to the ingestion of vegetables potentially grown in PAH-contaminated soil. All other zones and scenarios produced estimated hazard indices less than 1.0.

The UBK model predicted acceptable blood lead levels for future residents; however, at least one location near Building 656 may require further confirmation/remediation. Remedial action of soils in excess of the risk allowed by Massachusetts will be evaluated in the FS.

8.3 GROUNDWATER INVESTIGATION

An investigation was carried out to characterize groundwater upgradient of and beneath the facility. The present investigation consisted of installing 15 groundwater monitoring wells, while an earlier Phase 1 investigation consisted of installing 16 wells. One groundwater sampling round was completed and groundwater samples from the 31 wells were submitted to a laboratory for analysis of VOCs, SVOCs, TAL metals, cyanide, pesticides/PCBs, and radiologic parameters, including gross alpha, beta, and gamma activity and U-234, U-235, and U-238.

Assessment of groundwater consisted of comparing the analytical results to MCP groundwater standards and Massachusetts groundwater standards (314 CMR 6.06 and 6.07). No RA was completed for groundwater because groundwater in the vicinity of the site is not used as a water source and will not be used as one in the foreseeable future. Watertown is a MWRA member community and obtains its water supply from several reservoirs in Massachusetts.

8.3.1 UPGRADIENT WELLS

With the exception of MW-23, all upgradient wells showed detectable quantities of chlorinated solvents. Groundwater collected from MW-23 may have also contained chlorinated solvents; however, relatively high concentrations of BTEX compounds in this well required that the groundwater sample collected from MW-23 be diluted prior to analysis. This may have caused chlorinated solvent concentrations in MW-23 to fall below the quantification limit. Chlorinated solvents identified in upgradient wells include PCE, TCE, and TCA.

As mentioned, MW-23 showed elevated concentrations of BTEX compounds. Based on a site water table map, groundwater flow paths indicate the potential of groundwater flowing away from the site in an area in the Northwest part of the site before flowing towards the Charles River. No evidence of on-site contamination migrating off-site was found in groundwater collected from on-site wells. Most likely, a groundwater divide exists under a short stretch of Arsenal Street near the northwestern corner of the site; however, regional flow is toward the Charles River.



8.3.2 ON-SITE WELLS

Chlorinated solvents PCE and/or TCE were detected in groundwater samples collected from 12 on-site monitoring wells. Concentrations of PCE in on-site wells ranged from 1.3 to 93 ppb. Concentrations of TCE in on-site wells ranged from 1.5 to 94 ppb. Analytical results indicated that few VOCs exceeded state groundwater standards. Monitoring wells located in the western portion of the site reported the highest concentrations of PCE and TCE.

Elevated concentrations of SVOC 1,3-dimethylbenzene and volatile xylene were detected in well C-2. Based on a petroleum odor present during groundwater sampling, contamination is believed to be the result of a fuel oil release. Analytical results from nearby monitoring wells suggest the elevated concentrations are restricted to the area around C-2.

When completing soil boring 10SB-2, several inches of free product were observed at the water table. A petroleum fingerprint carried out on a soil sample collected at the water table indicated the contaminant was a fuel oil product. Groundwater samples collected from downgradient monitoring wells MW-3 and MW-4 did not detect evidence of the free product, indicating that there has not been contaminant migration in this direction. To determine more precisely the contaminant plume configuration, additional observation wells will be required. Extraction of the product will be considered in the FS.

8.3.3 GROUNDWATER RECOMMENDATIONS

Based on the results of the Phase 2 RI, WESTON makes the following recommendations regarding groundwater beneath the site.

Chlorinated solvents (PCE and TCE) were detected in 12 on-site monitoring wells. The impact of chlorinated solvents in locations where groundwater standards and regulatory standards were exceeded should be evaluated in the FS. Other monitoring wells were identified where groundwater exceeded groundwater standards.

High concentrations of 1,3-dimethylbenzene and xylene were detected in groundwater collected from well C-2. Based on additional groundwater monitoring and soil boring work completed in the area around well C-2, it is believed that the contaminant plume has not migrated beyond the area around C-2.

To better determine the plume configuration in the vicinity of boring 10SB-2, additional soil borings should be installed.



8.4 CHARLES RIVER INVESTIGATION

Surface water and sediment samples were collected at locations upstream and downstream of the storm sewer outfalls at MTL to determine what impact, if any, the runoff from the installation has had on the Charles River. Chemical data from the downstream samples for surface water were compared to available EPA and Commonwealth of Massachusetts criteria for protection of aquatic life or human use of the river. The sediment data were compared to the Draft National Sediment Quality Criteria (currently available for five compounds). A baseline RA for human health (Section 6) and an ecological assessment for MTL (future addendum) on the potential effects to native plants and animals provided further evaluation using the levels of contaminants found in the Charles River surface water and sediment samples. Both were performed in accordance with MADEP Risk Assessment Guidance.

Sampling Results

Ten metals and one organic compound were detected in the surface water samples collected from the upstream sampling locations. Sediments collected from the same five locations contained 15 semivolatile organic compounds and 19 metals. Many of the semivolatiles detected in the upstream sediments are contained in petroleum products. This, together with the observation of evidence of the long-term deposition of dark-colored organics (possibly heavy oil) indicate that the area immediately upstream of MTL has been influenced by the practices at the adjacent yacht club (see Figure ES-1 or Figure 4-10 for the location of the yacht club).

Eight metals were detected in downstream surface water samples at levels exceeding upstream concentrations. Of these, only chromium was detected in the downstream locations without also being detected in the upstream locations. Four organic compounds (toluene, ethylbenzene, xylene, and trichloroethylene) were detected in downstream surface samples, but not in the upstream samples. The first three compounds, are thought to be associated with fuel-related activities (e.g., filling fuel tanks on boats) at the yacht club.

In downstream sediment samples, 19 metals, 20 semivolatile compounds, and cyanide were detected. A total of 14 of these exceeded the upstream concentrations. Silver, anthracene, naphthalene, dibenzofuran, dibenzo(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and cyanide were detected in downstream samples, but not in the upstream samples.

Detected radionuclides exceeded the upstream concentrations in both surface water and sediments. In addition, these exceedances occurred in only five locations (mostly locations near storm sewer outfalls).

In summary, river contamination exists both upstream and downstream of MTL. The majority of the surface water contamination is located downstream of MTL influence, while much of the sediment contamination (especially fuel-related compounds) is upstream of MTL outfalls.



8.4.1 RISK ASSESSMENT FOR CHARLES RIVER EXPOSURES

The baseline RA for human health considered samples at or downstream of MTL. Risk scenarios were developed consistent with its classification as a Class B river by the Commonwealth of Massachusetts that is designated suitable for bathing and recreational purposes, public water supply with treatment, fish and wildlife habitat, and certain agricultural and industrial uses.

Risk levels were developed for the following exposure pathways:

- Ingestion of/dermal contact with surface water and sediment while swimming.
- Consumption of fish.

A review of the data indicated that selected organic and inorganic constituents exceeded background concentrations for both surface water and sediment at downstream sampling locations; however, the levels of risk derived from these exposure pathways and the concentrations of compounds found in samples at or downstream of MTL are as follows:

- The total potential carcinogenic risk for recreational use of the Charles River was less than the Massachusetts level of 1 in 100,000 and, therefore, less than the federal level of 1 in 10,000. The total estimated carcinogenic risk was 2 in 1,000,000 primarily as a result of potential ingestion of sediment.
- The total hazard indices for potential noncancer risk for the use of the Charles River did not exceed the Massachusetts limit of 1.0 and, therefore, was less than the federal limit of 1.0.

The draft ecological assessment for MTL focused on the potential effects on plants and animals from contaminants found in the Charles River surface water and sediment samples, as well as modeled concentrations of storm sewer surface water and sediments into the Charles River at the population, community, and/or ecosystem levels. Additional river sampling will be used to update the previous ecological assessment in the near future. The revised ecological assessment will be presented as an addendum to this RI Report.

In summation, levels of background and site-related contaminants in the Charles River surface water and sediment may have some adverse ecological effects; however, given the conclusions of the baseline RA, MTL has not impacted the Charles River to levels above which a 1 in 100,000 increase in cancer risk or acute or chronic human health effects may occur. In addition, remedial measures (e.g., dredging) in the Charles River would further disrupt the current ecosystem in the river and disperse additional contaminants; therefore, no remedial action is recommended at this time. A final



decision regarding remediation will be made once the ecological assessment has been completed.

8.5 STORM SEWERS INVESTIGATION

The storm sewer investigation consisted of flow monitoring and sampling of storm sewer runoff during a precipitation event, and an internal television inspection to investigate the integrity of the lines and possibility of groundwater infiltration. Background sampling points were used to determine the flow and contaminants contributed from off-site.

The storm sewers contained little or no sediment; therefore, only liquid samples were obtained during the precipitation event. Sampling results indicate that the site contributes small amounts of some metals and pesticides to the storm sewer runoff. The only metals that exceeded two times the maximum background values were copper and zinc, both of which also exceeded the typical urban runoff range. Confirmed pesticides concentrations exceeding two times background concentrations were alpha-, beta- and delta-BHC, chlordane, DDE, and methoxychlor. No radiological contamination was discovered.

Three storm sewer segments were inspected using TV. The TV inspection revealed that the lines were in good condition with some cracks attributed to natural deterioration. The cracks were found along the joints and sides of pipe constructed of vitrified clay and brick. Although cracks were found, there was no evidence of groundwater infiltration, past or present, in any of the segments investigated.

Access to the storm sewer is very limited; therefore, calculation of potential risks due to long-term exposures is not appropriate. Potential risks due to use of the Charles River, where the storm sewer lines discharge, were calculated (see Subsection 8.4); however, the risks calculated for Charles River use scenarios incorporate chemical and radiological contamination from numerous upstream sources (in addition to MTL storm sewer outfalls). Because of this and because very little sediment exists in the storm sewers, no remediation is recommended.

8.6 SANITARY SEWERS INVESTIGATION

Although not part of the original scope of sampling, sanitary sewers were investigated for radiological contamination. Sediment samples were collected from 12 sanitary sewer manholes. DU contamination was present in several manholes.

On Arsenal Street, uranium contamination was found in Manhole 93. The drainlines from Building 43 connect to the sanitary line at Manhole 93. Since uranium concentrations in Manholes 91 and 92, which are upstream of 93, are lower, the contamination in Manhole 93 appears to have been augmented by sources in Building 43. Further sampling, and possibly dye testing, will be needed to determine the source(s) of radiological constituents in Manholes 91 and 92.



On North Beacon Street, uranium was found in Manholes 120, 01, 78, 67, 36, and 35. Manhole 120 is the furthest upstream sample taken on the North Beacon Street sanitary line. The source of this contamination is unknown at present. Further sampling of manholes upstream of Manhole 120 will be performed, as well as tracing (via dye testing or an equivalent method), if possible, to locate any potential on-site sources of contamination.

Two sanitary sewer line segments were inspected using TV. The sanitary lines are in good condition with some cracks, as in the storm sewer lines. There was no evidence of past or current groundwater infiltration into the sanitary sewer lines. Because of the apparent integrity of the lines, infiltration of the contamination into the surrounding media is not likely.

Access to the sanitary sewer is very limited, so calculation of potential risks due to long-term exposures is not appropriate. Elevated levels of lead were found in several sewer sediment samples; therefore, the issue of remediation of chemical contamination in the sewers may have to be dealt with separately. More information should be collected from upstream manholes to determine whether the source of lead contamination is upstream of MTL or site-related. Removal of additional contaminated sediment will be evaluated in the FS.

The NRC has recently indicated that sediment in the sewer should contain less than 35 pCi/g of depleted uranium. Based on this ruling, remediation of sewer sediments may be required. It is not anticipated at this time that remediation will be necessary. In any case, sediments in sanitary sewer lines under much of Arsenal Street and North Beacon Street were already removed and drummed to allow a camera inspection of the lines. Radiologically contaminated sediments will be disposed of off-site.

Two sanitary sewer line segments were inspected using TV. The sanitary lines are in good condition with some cracks, as in the storm sewer lines. There was no evidence of past or current groundwater infiltration into the sanitary sewer lines. Infiltration of the contamination into the surrounding media is not likely due to the apparent integrity of the lines.

8.7 RADIOLOGICAL INVESTIGATION

The contaminated and suspected buildings were radiologically decontaminated during the period of August 1992 to May 1993. Each building was remediated and resurveyed to ensure that cleanup goals were met. Therefore, the description of radioactive contamination is no longer applicable. The extent of contamination observed during the Phase 2 RI is described here, but the description is not indicative of current conditions.

In addition to the soil, surface water, sediment, air, and sewer samples analyzed for radiological parameters, the following radiological investigations were conducted:



- Field instrument survey of the site grounds (outdoor survey) using an NaI Gamma FIDLER detector.
- Survey of indoor surface contamination via instrument surveys and swipe sampling of surfaces.
- Performance of borehole gamma radiation logging using a gamma detector.
- Performance of radiological contamination removability studies for select floor and wall areas, drains, and laboratory benches.
- Survey of building roofs and rafters using a pancake G-M detector.
- Survey of steam tunnels using a pancake G-M detector.

The field instrument survey of the site grounds (outdoor survey) indicated that the only outdoor surface gamma contamination was found in asphalt-covered areas with one exception, in soils outside the northwest corner of Building 39 south of Structure 229. Therefore, this contamination could possibly be attributed to elevated levels of natural uranium in the asphalt. In any case, with the one exception noted, it is doubtful that the elevated outdoor readings noted are a result of site operations. It is not anticipated that any remediation will be required.

The building interior instrument survey and swipe sampling program, the roof and rafter survey, and the removability study indicated that remediation of surface contamination in several areas is required and can be accomplished. These surfaces should be cleaned to levels below appropriate NRC standards. Buildings requiring remediation include 37, 39, 43, 97, 292, 311, 312, and 313. Areas within the buildings requiring remediation include walls, floors, sumps, roofs, rafters, and drain pipes. These remedial activities are discussed in the FDP (WESTON, 1992) and are ongoing.

Radiological sampling of the various environmental media at the site (Charles River, surface and subsurface soils, storm sewers, and groundwater) and of the indoor air and the containers indicated that detectable levels of radiological parameters do exist in select samples, but at low concentrations that do not pose a human health risk at MTL, even under hypothetical future residential use of the site (see Subsection 6.7).

The radiological investigation can be divided into two sections: environmental media, when the need for remediation is based on the RAs; and buildings to be remediated as part of facility decommissioning. No remediation is required in environmental media at MTL due to radioactivity, but remediation was performed in various operations areas of the site as part of decommissioning. The decommissioning methodologies for these areas are described in detail in the FDP (WESTON, 1992).



8.8 INDOOR SURFACE CHEMICAL INVESTIGATION

Indoor surface chemical wipe samples were taken from 855 locations in 17 buildings/structures at MTL and 4 off-site (background) buildings. Background samples taken off-site contained a total of 6 organic and 16 inorganic contaminants. Since neither the EPA nor the MADEP has promulgated guidelines or protocols for allowable surface contamination, the wipe sample results could not be evaluated in the baseline RA; however, guidelines were calculated based on protocols used by the State of New Jersey to establish surface contamination action limits. Contaminants that exceeded the calculated guidelines were considered elevated. Conclusions from the on-site surface wipe investigation are discussed below:

- Rooms in Buildings 111, 118, 131, 243, 292, 311, 312, 313, 36, 37, 39, and 43, and the bunkers had levels of at least 1 analyte in samples above calculated guidelines.
- Buildings 243, 292, 311, 312, 313, 37, 39, and 43 had the most analytes above calculated guidelines.
- Many occurrences of elevated levels of chemicals were consistent with past
 uses in the particular buildings or rooms. For example, rooms in
 Building 312 were the only locations where wipe samples contained
 elevated levels of beryllium.

Various decontamination techniques to be implemented on building surfaces with concentrations exceeding the calculated guidelines will be evaluated in the feasibility study. Some areas will already have been remediated as part of the facility decommissioning, due to the presence of low-level radioactivity on various surfaces. These areas include rooms/areas in Buildings 39, 43, 97, 292, 311, 312, and 313. Potential remedial methods for surficial radiological contamination are outlined in the Facility Decommissioning Plan (WESTON, 1992).

8.9 AIR INVESTIGATION

Air samples were collected from Buildings 36, 37, 39, 43, 60, 97, 131, 241, 243, 292, 311, 312, and 313. Samples were analyzed for VOCs, PAHs, PCBs, metals, explosives, and radiological parameters. Samples were collected as 24-hour composites, and sample receptacles were placed in central locations in each building so as to assess the air within the building as a whole. Background samples were collected from six outdoor areas. Results of background samples were compiled. For each sample, comparisons of analytical results to ARARs for both occupational and public health exposure scenarios were made. In no instance were public health guidelines or occupational exposure limits exceeded.

For the following reasons, remediation of indoor air at MTL is not recommended:

No health guidelines were exceeded.



- The cessation of current site activities and remediation of indoor surfaces would eliminate the presence of on-site surficial contamination that may become airborne.
- In many instances, outdoor levels exceeded those indoors. It is believed that most of the air contamination is from outdoor air entering the buildings.

Rather than remediate interior air, it is recommended that surfaces be cleaned (see Subsection 8.8) and the air be monitored during and after remediation of building interior surfaces.

8.10 CONTAINER INVESTIGATION

A total of 26 cisterns, tanks, sumps, and dry wells were sampled as part of the Phase 2 RI effort. In all, 31 samples were collected. These were either water or sediment samples. Depending on their availability at the time of sampling, both water and sediment samples were collected. Where sample volume permitted, samples were analyzed for volatile and semivolatile organics, metals, pesticides, PCBs, and radiological parameters. No USTs were sampled as part of this effort, because as of the writing of this report, all identified USTs have been removed from MTL.

Results of sampling indicated that containers in or associated with buildings historically engaged in radiological laboratory or manufacturing processes contained radiological contamination, usually in the form of DU. Radiological contamination in the reactor area was composed of other radioisotopes, such as cesium and thorium. Eighteen radiologically contaminated containers were remediated as part of the facility decommissioning (WESTON, 1992). This is in large part because during decommissioning, the structures surrounding these containers were removed (reactor) or otherwise remediated (Building 43). The status of the containers is presented in Appendix T.

Data from 23 of the 26 container samples indicated that one or more RCRA metals were identified. PCBs were detected in three of the containers sampled. Several outdoor container samples contained various pesticides (samples from the dry well near the propellant storage area, and samples from cistern 243). This is expected when infiltration of outdoor overland flow into the containers is considered. PAHs were detected at various concentrations. VOCs were detected at generally low concentrations.

A number of analytes, compounds, and radionuclides were detected; however, the likelihood of human exposure to these contaminants is extremely low. For this reason, container samples were excluded from the RA calculations in Section 6, and no human health or ecological risks for these sources were computed. Additionally, these results must be considered in light of the fact that no true background or comparison standards exist for these samples. It is difficult to locate background container samples, since by their nature, they retain contaminants in greater concentrations than



environmental media, such as rivers. This tendency would force a comparison to render many more "contaminants of concern" than would a comparison of upstream and downstream river samples, for instance.

One would expect to find chemicals in cisterns, sumps, etc., in a municipal setting. This, taken with the low probability of human contact with the container contents, indicates that remediation of the containers for protection of human health is not necessary.

For the purposes of "good housekeeping" and for a smoother transition during future transferral of the MTL property, however, WESTON recommends that all containers in which hazardous constituents have been identified be decontaminated by removing the current container contents and managing the wastes appropriately. The inventory of the containers should be reviewed quarterly by the facility until all containers have been decontaminated. As stated above, complete remediation of the containers, such as removal or encapsulation, would not be necessary, as no imminent threat to public health is presented by the containers. Simply removing the container contents (in conjunction with a cessation of site activities that would generate hazardous materials that might continue to collect in the containers) would be sufficient.

8.11 SITEWIDE RISK SUMMARY

Exposure profiles were developed for two residential populations—adults and children—at four zones across the site. The residential profiles included exposures both at home and at site recreational areas. At each of these zones, carcinogenic risk estimates exceeded 1E-05, indicating that remedial measures should be pursued if these areas are to become residential. Carcinogenic risks were highest at Zones 1 and 4 (2E-04 to 7E-04), where exposures to vegetables grown in contaminated soils were included. Carcinogenic risks in Zones 2 and 3 ranged from 6E-05 to 7E-05. The PAHs detected in soil are the primary contributors to this risk. Radiological carcinogenic risk estimates for residential populations were all within the acceptable range (i.e., less than 1E-05).

Hazard indices calculated for resident children were all below 1, except in Zone 4. At that location, an HI of 2 (due to the presence of pesticides) was calculated for the vegetable pathway. This indicates that the area may require remediation if residential development, including vegetable gardening, were to occur. Although the UBK model predicted acceptable blood lead levels for children who might live in these zones, it was recognized that at least one location near Building 656 may require further investigation and/or remediation if a child resident were to preferentially ingest soil from that area.

Use of the park area and the Charles River by visitors resulted in a total potential carcinogenic risk of 1 in 100,000 and a HI of less than 1.0.

Exposures profiles were also developed with the assumption that Zones 1, 2, and 3 could be developed commercially. There appears to be no health concern for workers



in a commercial setting exposed to soil from surrounding outdoor locations except in Zone 3 where the estimated cancer risk is 2E-05. Noncancer and radiological risk estimates are all within acceptable ranges.

There appears to be no health concern for construction workers who could be exposed to site contamination during future building type activities. Estimates for carcinogenic risk (chemical and radionuclide) and the hazard indices are within the acceptable risk range.

Section 9 References



SECTION 9

REFERENCES

9.1 REFERENCES FOR SECTIONS 1 THROUGH 5, AND 8

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9-4



MTL Employees Interviewed:

Major Adams - Commander/Deputy Director (D)

Robert Chase - Chief Risk Management Officer (RK)

Sam Gilfix - Environmental Manager (RK)

Peter Connetta - Radiation Protection Officer (RK)

Ron Allen - Environmental Specialist (RK)

Don Crowell - Safety Engineer (RK)

Captain Howard - Health Physicist (RK)

Carmine Aceto - Safety Inspector (RK)

Paul Black - Health Physicist (RK)

Chuck Paone - Public Information Officer (COMDR)

Joe Miliano - Chief Facilities Engineer (FED)

Dave Gerety - Chief Engineering Services Branch (FED)

Jack Winslow - Staff Engineer (FED)

Randy Tow - Electrical Engineer (FED)

Walter Eades - Chief, Utilities Buildings and Grounds (FED)

Dick O'Brien - Chief, Fab Tech Demo Branch (MEF)

Arthur Shepherd - Physical Science Technician (MEF)

Francis Hanrahan - Physical Science Technician (MEF)

Laura Rodman - Action Officer (BRAC)

Eric Engwell - Chemist (EMP)

Fred Sceitsinger - Supervisory Engineering Technician (MED)

Bob Pasternak - Test Engineer (MRM)

Wai Chen - Chemist (MRM)

Notes:

BRAC = Base Realignment and Closure

COMDR = Commander

D = Director

EMP = Emerging Materials Division FED = Facilities Engineering Division MEF = Materials Exploitation Division MRM = Materials Reliability Division RK = Risk Management Division

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